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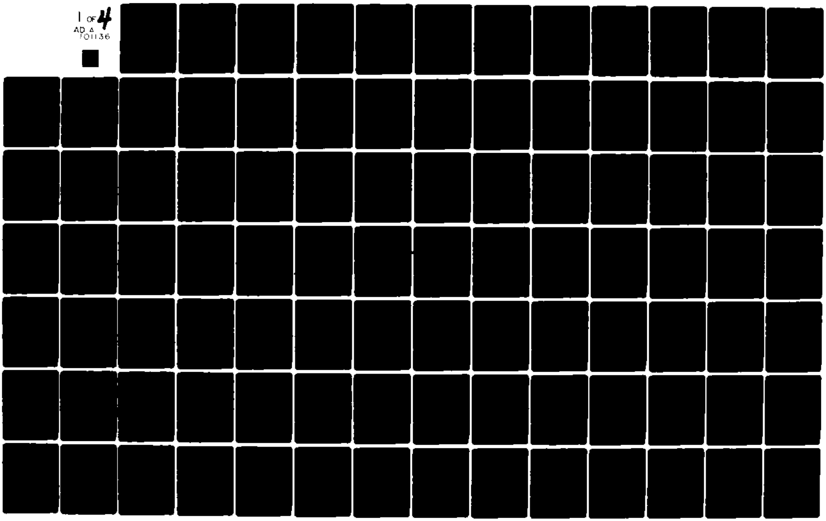

AFIT/GST/OS/81M-1

QUANTIFYING REACTIVE MANEUVERS.

THESIS

AFIT/GST/OS/81M-1 John J. Alt
Capt USAF

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QUANTIFYING REACTIVE MANEUVERS

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

by

John J. Alt, B.S., M.B.A.
Capt USAF
Graduate Strategic and Tactical Sciences

March 1981

Preface

This study was undertaken because of interest from the Strategic Air Command (SAC) and the Air Force Avionics Laboratory (AFAL). Mr. James J. Foreman of the AFAL was instrumental in helping with the formulation of the experiment which was the heart of this research.

In the course of the study, I found that the elements for determining a value for reactive maneuvers are available. I identified those elements and hope to pursue this research at a later time.

I am thankful for the continuing assistance of Mr. Foreman throughout this study. I am grateful to Lt Colonel Pete Bobko, my advisor, and Major Dan Fox for their guidance and support during this thesis. I would also like to thank the following individuals for their material support. They are Mr. William McQuay (AFAL), Captain Dick DeRoos (SAC), and Dr. Robert Nullmeyer and Mr. Dave Grove of the University of Dayton Research Institute. Finally, I wish to express my appreciation to my wife, Sheri, for her patience and support, and for typing this final manuscript.

John J. Alt

Contents

Contents

List of Figures

List of Tables

Abstract

There is currently no value of survivability attributed to an aircraft's reactive maneuver capability. In this experiment, exposure to enemy ground threats for various levels of information feedback to the aircrew were compared. This was done in an attempt to isolate the maneuverability factor. The Threat Model Penetration Simulation Analysis (TMPSA) model produced by the University of Dayton Research Institute was the penetration model used. The conclusion of this experiment was that only order of magnitude differences in capabilities can be captured with this model. It is recommended that two simple changes be made to TMPSA. These changes would allow more precise values for reactive maneuvers to be derived.

QUANTIFYING REACTIVE MANEUVERING

I. Introduction

The purpose of this research was to examine the problem of quantifying aircraft maneuvering in response to electronic warnings of ground based threats. The objective is to examine one approach to solving the problem of quantifying aircraft maneuvering.

The research is limited to examining only bomber-type operations. It is hoped that the methodology developed can be extended to other aircraft by making the minimum number of assumptions necessary to achieve the objective stated above.

The EW Planning Process

Planning bomber operations begins with receipt of the target list. In the case of the Single Integrated Operations Plan (SIOP), this is prepared by the Joint Strategic Target Planning Staff (JSTPS). Strategic Air Command then plans aircraft sorties based on the targets on the list. In a conventional war, targets are assigned by the theater commander. In this instance, the bomber planners are cooperating with the theater commander's staff to develop the operations plan. Figure 1 shows generally how an electronic warfare (EW) plan is developed.

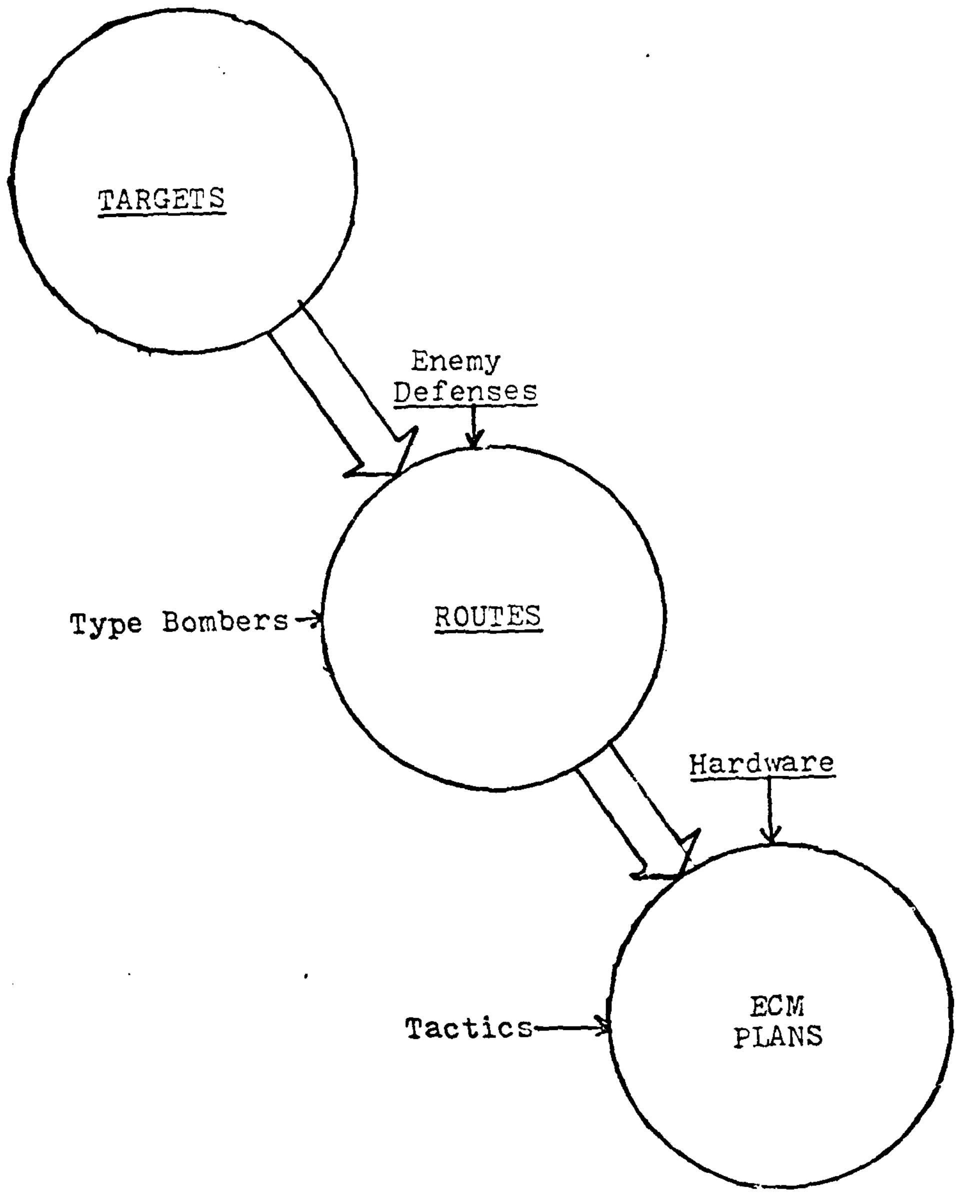

Fig. 1. The Bomber EW Planning Process

With the targets assigned, the planners must now determine a feasible route for the bomber force. The goal is to achieve the objective, target destruction for example, with minimum losses. It is the responsibility of the Electronic Warfare Support Division (ESM) to gather information on the nature of the enemy's electronic defenses. The ESM staff is usually part of the intelligence directorate. With the raw data gathered by ESM operations, as well as other intelligence sources, an enemy radar order of battle is developed. The type of radars and their locations, functions, and characteristics are determined or estimated. This intelligence estimate is used to plan the aircraft routes. Known point defenses, such as surface-to-air missiles (SAMS) and anti-aircraft artillery (AAA), are avoided. Weaknesses in the electronic defensive network are exploited. Some of these weaknesses may be gaps in the radar coverage, low saturation level of the local command and control net, and poor types of equipment. Where electronic defenses must be penetrated, detailed information on these defenses is made available to the aircrews for study. With tentative routes established, the Electronic Countermeasures (ECM) plan is prepared.

The ECM plan consists of determining what hardware and tactics to use on the mission. The hardware is made up of the aircraft selected for the primary mission and the aircraft selected for support roles. Selection of the bomber is based on performance characteristics, such as range and speed, as well as ECM capabilities. Some bombers, such as

the B-52, have an assigned strategic mission. In this case. the ECM equipment on the airplane is tailored to the strategic mission. Some bombers do not have adequate built-in ECM equipment. On some missions, even the extensive equipment on a B-52 may not be sufficient to ensure a high probability of success. In these cases, support aircraft may be included as part of the plan.

Two examples of ECM support aircraft are stand-off jam (SOJ) platforms and defense suppression aircraft. The SOJ platform has a pure jamming and deception role. The SOJ aircraft flies out of enemy weapons range and uses high powered electronic equipment to jam and confuse enemy radio and radar operators. The primary defense suppression aircraft is called the Wild Weasel. The job of the Wild Weasel is to find enemy radar controlled SAM or AAA batteries and destroy them. Selection of the hardware depends on the tactics to be used; and the tactics to use depends on the hardware. That is, tactics and hardware are interdependent.

The ECM tactics employed are primarily dependent on the type of operation. The timing of the SIOP is designed in such a way that the bombers saturate the enemy's defenses in one area, then fly individual routes to the targets. During the initial phase of tha attack, the bombers support each other electronically. As the bombers diverge, the individual routes are designed to exploit enemy electronic weaknesses, such as those mentioned above. Each aircraft must then be prepared to defend itself. The self-protection tactics used

are developed by determining what equipment the enemy has and how he uses it, developing and testing new ECM equipment or tactics to counter the enemy capability, and training the crews to use the equipment and tactics thus derived (see Figure 2).

This same process is followed to develop the equipment and tactics for the use of massed bombers in a tactical operation. In the case of a tactical operation, self-protection may not be part of the ECM plan. Many other tactics are available. These ECM tactics include defense suppression, stand-off-jamming, chaff clouds or corridors, electronic confusion, and electronic saturation through the use of decoys. Thus, the choice of tactics is based on the type of operation, the hardware available, the routes chosen, and the targets assigned. None of the criteria for electronic warfare (EW) planning mentioned above is considered in isolation. The routes, targets, hardware, tactics, and type of operation are interdependent. Each is considered in light of the others before the final operations plan is established.

The Problem

This description of EW planning is only an overview. The interdependence of the planning factors coupled with the growing diversity of the enemy's anti-aircraft equipment and organization pose complex problems for the operations planners. Many of these problems have been solved through the use of computer models and simulations. Models have been devised to measure the effectiveness of ECM equipment against radars of

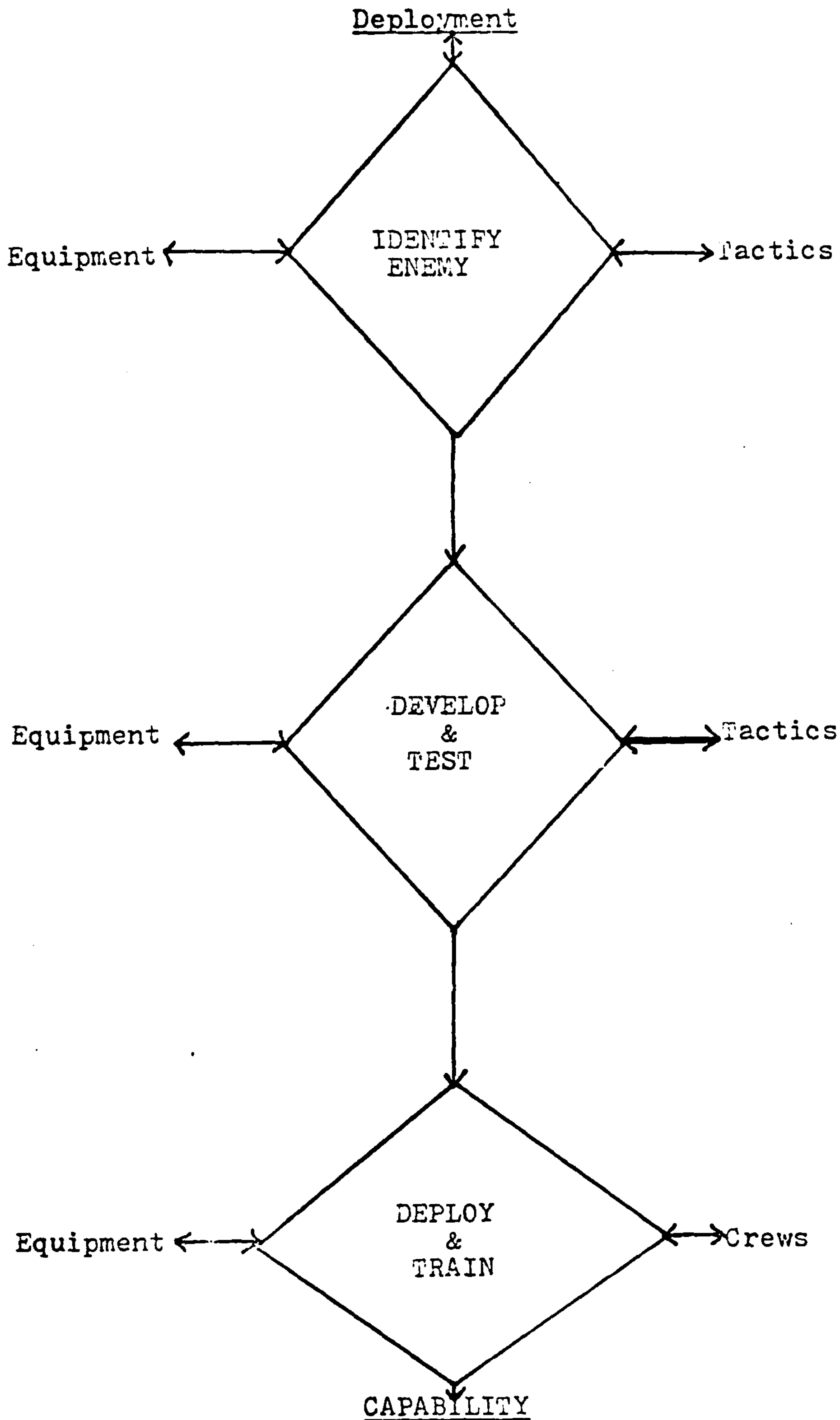

Fig. 2. ECM Tactics Development Process

most types. Models for many different scenarios have been developed, but none of these models has successfully included reactive responses (Ref 1).

One of the specific problems of this genre concerns determining a value, or modeling an aircrew reaction to a perceived threat. Although the problem of how to model maneuvers has been present in the past, recently it developed a greater importance.

The increasing mobility of the Soviet anti-aircraft forces is significantly complicating the job of operations planners. All of the latest Soviet anti-aircraft equipment is mobile (Ref 13:49). As a result of this mobility, a number of EW planning tactics are no longer as useful as before.

One of the main tactics of the EW planner is to avoid enemy defenses. As a result of the enemy's mobility, the planner is reduced to planning based on uncertain defensive positions. Avoidance is not as credible a tactic in this situation.

A second tactic, which is severely degraded by enemy mobility, is exploitation of the enemy electronic defense network. With a mobile air defense force, the enemy is capable of filling gaps in radar coverage; and, he can move equipment to locations where poorer equipment is operating. Today's weak spot may be tomorrow's strong point. Thus, the value of another tactic is reduced.

The last problem caused by the mobile defense concerns the impact on the aircrews. Before the mobile forces were

deployed, the crew could study a mission and be well prepared for the defenses to be encountered. Now the aircrew must be prepared to counter any and every threat the enemy can field.

As a result of the above, most of the problem of defeating enemy defenses rests on the aircrew's reaction once the threat is perceived. The planner's problem remains one of determining the best application of the forces available. This problem is complicated by a more dynamic battle situation.

The key factors of the problem of aircrew reaction to perceived threats are the aircrew detecting the enemy radar, the enemy radar operator identifying the bomber, and the subsequent reactions of both sides in the ensuing battle. If radar or some other electromagnetic device is not used, the situation is not an EW problem and is beyond the scope of this paper.

The aircrew detection and enemy radar operator target identification processes are two sides of the same problem. When the radar detects the bomber, the radar operator must see the "blip" on his scope and determine that the blip represents a bomber. Conversely, when the radar signal triggers the electronic warning equipment on the bomber, the aircrew must recognize the signal and the weapon type the radar supports. Although the problems of aircrew detection and radar operator interpretation are beyond the scope of this paper, the reaction times determined in the studies of these problems can be used in the research model.

The second key factor of the problem is responses of the

operator or crewmember to the detection. The specific actions of the radar operator are beyond the scope of the paper, except that they result in firing of a SAM or AAA.

The reaction of the aircrew can be active electronic countermeasures, physical maneuvering of the aircraft, neither of these tactics, or both of these tactics. Active electronic countermeasures are jamming the enemy radar signal, dropping chaff, and employing electronic deception techniques. Consideration of these reactive tactics is beyond the scope of this study. The problem of reactive ECM is an area that has not been modeled as yet. It is a considerably more complex problem than the problem to be addressed.

The second possible action available to the aircrew is to maneuver the aircraft to minimize exposure to the ground threat. This is an application of the avoidance tactic. As stated above, the objective of this paper is to examine an approach to solving the problem of quantifying the value of reactive maneuvering. With this value determined, the planning staff will have a better understanding of how much force will be necessary to achieve an objective.

Review of EW Modeling

Modeling EW is a relatively new development. The introduction of sophisticated radar-directed anti-aircraft weapon systems by the Soviets resulted in the need to develop airborne systems that warn aircrews of the impending attack. Other equipment was needed to deny the enemy radar operator location information about the aircraft. Modeling and

simulating developed as tools to evaluate ECM equipment and tactics.

One of the earliest comprehensive efforts at simulating EW was the formulation and construction of the USAF REDCAP electromagnetic simulator in 1964-1965. The simulator was capable of evaluating ECM equipment against a single tracking radar. More radar channels and a variety of capabilities, such as chaff simulation, have been added to the simulator. Today the system is capable of simulating an entire air defense region against an attack by hundreds of aircraft. This simulator has been used extensively by the U. S. Air Force to evaluate tactics, ECM concepts, and EW hardware (Ref 3:1-2).

The history of the REDCAP simulator is a typical example of how simulation of EW by digital computers has grown. Today there are many models of air warfare which include EW (Ref 1). However, none of these models has adequately modeled reactive EW, including maneuvers (Ref 5).

A model, called the Threat Model Penetration Simulation Analysis (TMPSA), was developed for the Air Force Avionics Laboratory by the University of Dayton Research Institute to determine whether more accurate knowledge of threat location by a penetrator would enable the aircraft to increase its probability of survival. In the model, an aircraft seeks to maximize its probability of survival given knowledge of all threats lying within a certain distance (Ref 19:1-2). This flight path generation model is a first step in putting a value on maneuvers. The model accomplishes this by attempting

to minimize the amount of time the aircraft is exposed to lethal enemy ground fire. This research effcrt proposes to improve TMPSA as described above by refining the assumptions and explicitly accounting for some uncertainties assumed to be constants in the TMPSA model.

The Approach

The approach used is to compare feedback loops to determine a minimum lethality time. Feedback loops are information flows. The specific loops used are described later. The minimum lethality time is a function of the lethality of a defensive system at various ranges and the amount of time the aircraft spends within these particular weapon ranges.

In the postulated situation shown in Figure 3, the aircraft must navigate from the starting point (S) to the finish point (F). The aircraft track is denoted by the dotted line. The solid parallel lines represent the corridor the aircraft must remain within. When maneuvering is allowed, these represent the maximum lateral travel allowed for the bomber. Each circle represents a fixed enemy SAM or AAA unit. Three types are noted in Figure 3 as T_1, T_2, and T_3. The total lethality time is computed by multiplying the amount of time the aircraft is in each circle, which is a constant (Δt), by the lethality of the circle (P^T_{k1}, P^T_{k2}, P^T_{k3}). The approach used in the TMPSA model is to divide the lethal radius of the SAM or AAA battery into segments with an assigned probability of kill based on the range and azimuth of the aircraft to the battery site (Ref 19:2). Figure 4 is an example of a

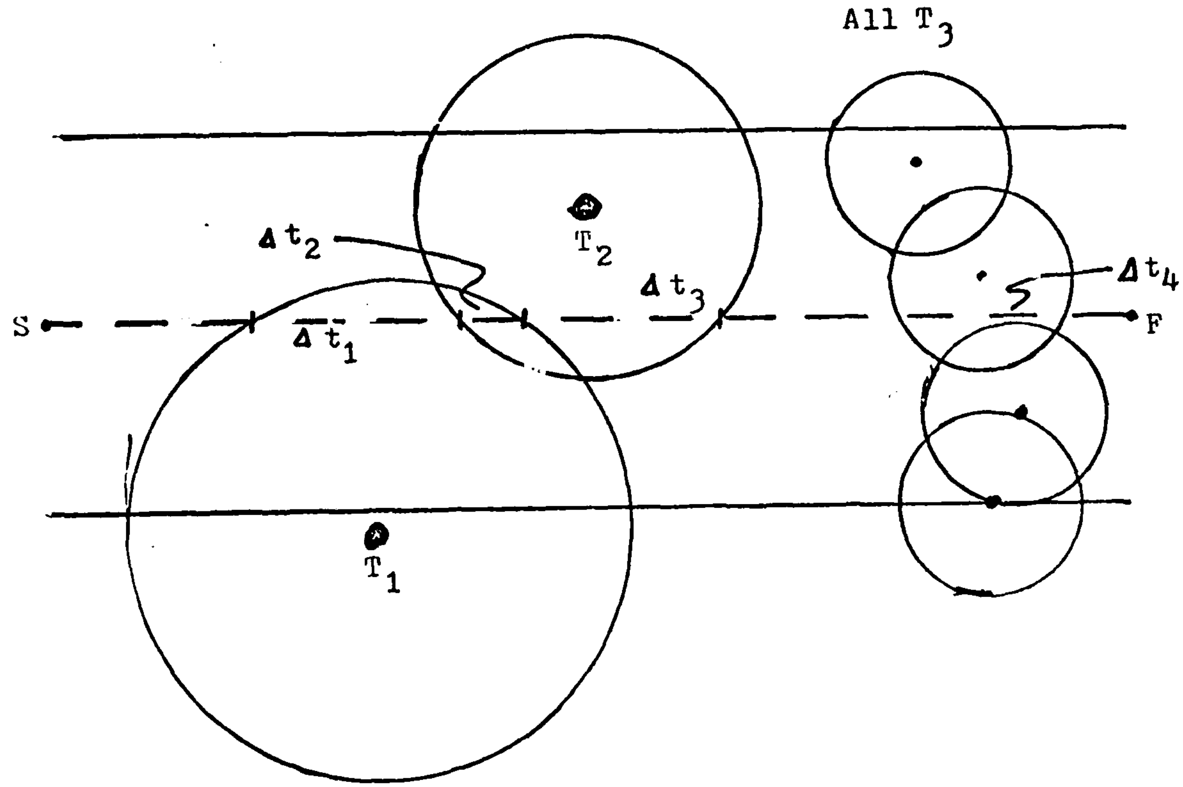

Fig. 3. Generalized Mission

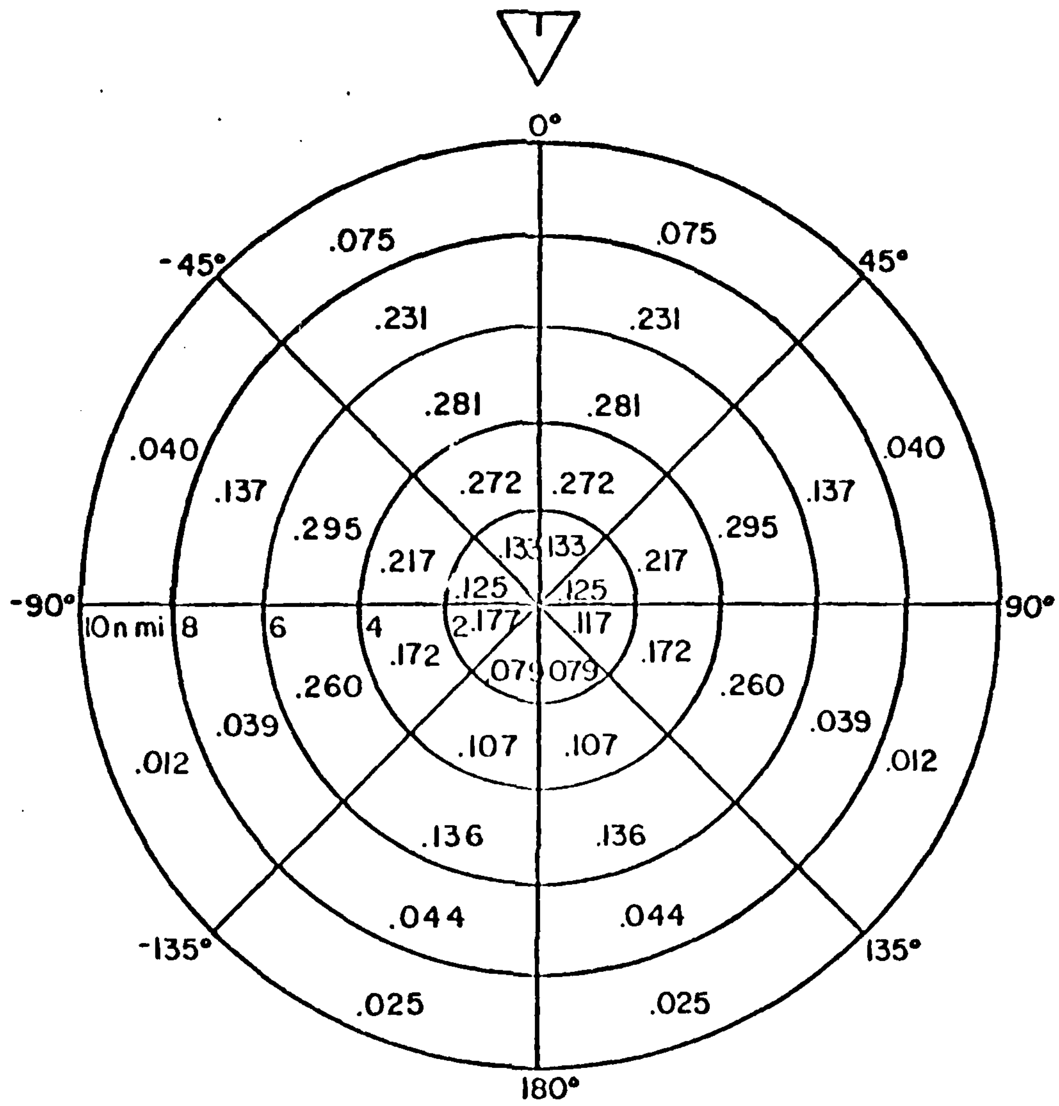

Fig.4. Example Antiaircraft Site Template

site template used in TMPSA.

Three levels of feedback will be examined. First, the situation will be considered with no feedback. Next, a feedback loop will use the TMPSA model flight path generator to determine the reaction with perfect information. The final feedback loop will attempt to model manual reaction based on less than perfect knowledge about the enemy defensive system locations. The missions with these three levels of feedback will be called the preplanned mission, the automatic mission, and the manual mission.

The purpose of the preplanned mission is to determine the total lethality time of the aircraft in the situation when no knowledge of the threats is available to the aircrew. In this situation, the aircraft is flown over its preplanned route and its total exposure to lethal enemy weapon effects is computed.

The preplanned mission will be constructed using the mission planning assumptions of an operational Air Force staff against a random distribution of ground threats. As part of the study of the unplanned mission, an additional unplanned threat will be introduced. The new situation posed by this threat will be examined to see how it changes the total lethality of the penetration. The threat location will be changed for each iteration of the model so the entire gamut of interactions from collocation with other defenses to no overlap of defensive fire can be examined.

The automatic mission will start with the same mission

as the preplanned, but as the airplane penetrates, the crew is assumed to have perfect knowledge of where all threats are once they come within the awareness range of the penetrator. Again, the total lethality will be determined, but this time the crew will be allowed to react based on the given information. As a variation of the automatic mission, a second set of lethalities will be computed for the case where small, random range and azimuth errors occur, thus simulating sensor limitations. In this variation the crew will no longer have exact knowledge of the threat location. Both of these automatic loops will use the flight path generator of TMPSA to determine the aircrew reaction to the threat.

In the manual mission, the input to the crew will be similar to the imperfect automatic loop. Crew reactions will be modeled based on reaction times from studies of human responses and the tactics prescribed by the major commands for these type engagements. The result will be lethalities as in the earlier cases.

This step-by-step approach to the problem should result in a realistic value for aircraft reactive maneuvering. This algorithm and the value it produces for maneuvering should enable planners and decision makers to employ forces more efficiently. An interesting result of determining the maneuver value is that it provides a way of determining the value of knowledge of enemy defensive locations. The emphasis of the approach, however, will be to proceed in small increments to achieve the objective of quantifying reactive maneuvering.

Chapter II The Preplanned Mission

Introduction

The purpose of this chapter is to establish a control model and scenario against which later refinements in the model can be compared. To this end the relevant planning assumptions used by the JSTPS will be outlined. Using these assumptions, a route segment will be defined, a threat array established, and the threat site template described. With these parameters established, the first basic model will be defined and run results shown. Finally, an additional threat will be added to the scenario and the model will be adjusted to treat this threat as having an uncertain location. This second basic model will serve as the control model.

JSTPS Planning Assumptions

The JSTPS attrition methodology applies the threat model to the penetrator on a one-on-one basis. The output of each engagement is a probability of kill (P_K) of the penetrator. These probabilities are then combined in series to yield a probability of arrival (P_A) at any particular point along the penetrator route. The computation is accomplished as follows:

$$P_A = (1-P_{K1})(1-P_{K2})\ldots(1-P_{KN}) \qquad (1)$$

for N threats encountered (Ref 17:3-4). In Chapter one, it was stated that comparison between the control model and the

modified models would be based on the lethality time. Since the JSTPS model determines a probability of arrival, these two approaches must be reconciled.

The JSTPS attrition model computes a probability of kill (P_K) for each threat site encountered. The P_K is a function of the probability that the threat successfully 1) detects and tracks the penetrator (P_d), 2) fires its weapon (P_s), and 3) the weapon, missile or AAA rounds, cause lethal damage to the penetrator (Ref 17:8-10). Mathematically this is:

$$P_K = (P_d)(P_s)(P_k)$$

Time is treated by determining how many shots (N) the site can make before the penetrator is out of enemy weapon range. This computation considers the geometry of the penetrator and threat site engagement, and the ability of the threat site to reengage the penetrator (Ref 17:11). This results in the P_K formula being revised slightly.

$$P_K = (P_d)(P_s)\left[1-(1-P_k)^n\right]$$

When all P_K's are derived for the aircraft route, Equation 1 is used to compute the probability of arrival.

The TMPSA methodology is different in the way it treats time and in the resulting output. Each threat site template has a probability of kill for each segment. These probabilities are static probabilities which are functions of the range and azimuth of the penetrator to the site (Ref 19:2-5). The TMPSA program sums all the kill probabilities for all sites within whose lethal range the aircraft is located (P_{KT}).

Then the incremental lethality time, called exposure (ΔE), is determined by:

$$\Delta E = P_{KT} \cdot \Delta t$$

where Δt is the time increment. Total exposure E over an entire flight path is then:

$$E = \sum_{N} (P_{KT})_N \cdot \Delta t$$

where N is the number of time increments in the flight path (Ref 20:3-4).

The lethality time and the probability of arrival are determined by the same inputs. However, the TMPSA methodology considers the penetration problem using a fixed time increment. The JSTPS methodology is event oriented where time is a subroutine. The result is that TMPSA produces a scalar output (probability X time) and the JSTPS model produces a probability output (probability). The TMPSA result is a lethality time that is inversely related to probability of arrival (Ref 20:1).

Mission Segment Definition

For this research, a route segment was constructed based on the start and finish points, the track the aircraft flies, the distance from start to finish on track, and the speed of the penetrator. The symbols and their definitions for constructing the route segment are noted below.

XI = the starting point for the aircraft and the zero time location.

XF = the finish point for the aircraft and the run stop time.

T = a straight line between XI and XF representing the penetrator track.

Any point on the ground can be measured from a point on the track by noting distance and angle measured clockwise from the track. Thus, along track is zero degrees. Although not too important in this model, it will have more meaning in later developments.

D = distance measured in kilometers between any two points on the ground.

VMN = speed of the penetrator. In this model, the speed will be constant.

The last two parameters need further definition. The route segment is set at 100 km and the speed of the penetrator will be set at 350 knots. The length of the route segment was set arbitrarily. The sensitivity of the model to route length will need to be examined later. The penetrator speed represents a common B-52 low altitude training speed. As noted in Chapter one, bombers are being modeled. This is sufficient for this model, however, later model development will require specifying minimum and maximum speed limits. With the route segment defined, the threat array must be set.

Threat Array Determination

For this model, an artificial threat array is generated and threat system parameters will be arbitrarily selected.

However, for planning an actual bomber sortie, this would obviously be unnecessary. Having noted these caveats, the threat array determination method is outlined below.

A three-step method was used to establish the strategic (ie. fixed site) threat array. First, a corridor on each side of the penetrator track was set based on the maximum threat range. For this model, all threats represented the same weapon system. Next, a grid system was devised as a way of locating points on and around the route. Finally, ten random numbers were selected to locate each threat on the grid system.

Since the corridor limits depend on the range of the threat system in this model, the first step was to determine the threat range. In this case, the threat range was arbitrarily set at 10 km. The corridor width was selected to be 20 km (10 km on each side of track). For this corridor, a grid of one kilometer by one kilometer squares was considered appropriate. To establish the ten threat locations, ten random numbers were selected from the CRC Standard Math Tables (Ref 2:545). Lines one through ten of column eight were selected as the random number stream. The first two digits were taken as the x coordinate. The middle digit was ignored. The y coordinate was determined by the last two digits. The fourth digit was reduced to a zero or one. If the fourth digit was even, the digit became a zero, if odd, it became a one. The revised fourth digit and the fifth digit represented the y coordinate (eg. 75 translated to 15 and 85

translated to Ø5). Table 1 shows the random numbers and the x and y coordinates derived. It later became evident that threats were needed outside the corridor. For this reason, another 27 random numbers were selected from the CRC Tables, column 7. The grid was expanded to include a distance equal to the awareness radius from each corridor at 25 km. In effect, the grid was now 70 km by 100 km. To establish each plotted position, the random number was divided as before. The first two digits represented the x coordinate. The middle digit was ignored. The y coordinate was more difficult to compute. If the fourth digit was zero through four, it was not changed. If it was five through nine, five was subtracted. If the last two revised digits were greater than 25, then 20 was added to the number to obtain the y coordinate. Otherwise, the last two digits are the y coordinate. Figure 5 is a plot of the final array. The final step in building the basic model was to define the threat template.

Threat Template Defined

The threat template represents the lethality of the threat system by range and azimuth of the penetrator from the threat site. The lethal radius of the threat system is divided into segments with an assigned probability of kill (P_K), as shown in Figure 4 (see Chapter one). As an aircraft transits a segment, the total lethality time of the penetrator is incremented by the segment P_K for each increment of time the penetrator is in the segment. Each segment P_K, in other words, represents lethality as described earlier

TABLE 1

Random Threat Site Location

Site Number	Random Number	Coordinate x	Coordinate y
1	14194	14	39
2	53402	53	27
3	24830	24	35
4	53537	53	42
5	81305	81	30
6	70659	70	44
7	18738	18	43
8	56879	56	44
9	84378	84	43
10	62300	62	25
12	69179	69	49
13	27982	27	52
14	15179	15	49
15	39444	39	64
16	60468	60	18
17	18602	18	02
18	71194	71	64
19	94595	94	65
20	57740	57	60
21	38867	38	17
22	56865	56	15
23	18663	18	13
24	36320	36	20
25	67689	67	59
26	47564	47	14
27	60756	60	06
28	55322	55	22
29	18594	18	64
30	83149	83	69
31	76988	76	58
32	90229	90	49
33	76468	76	18
34	94342	94	62
35	45834	45	54
36	60952	60	02
37	66566	66	16
38	89768	89	18

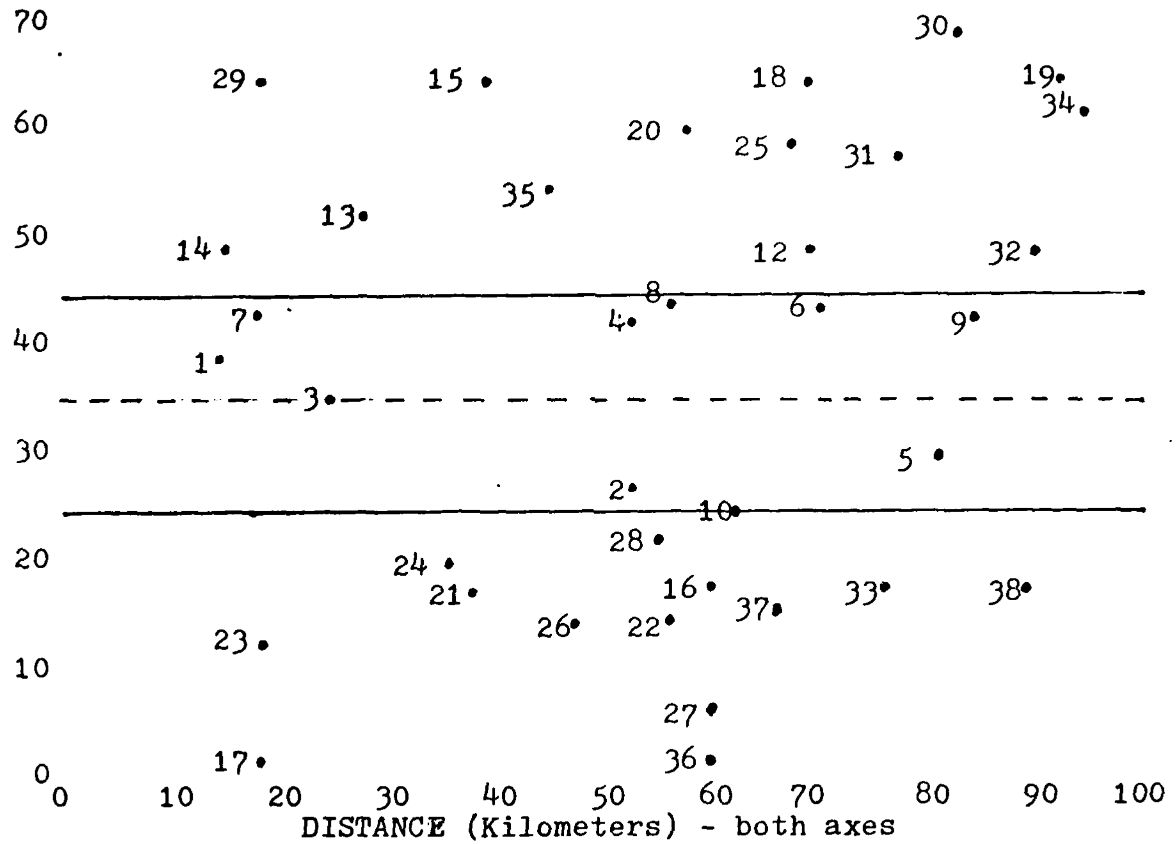

Fig. 5. The Basic Scenario

in this chapter.

For this research, the threat template used was exactly the same as the template shown in Figure 4. The segments are two kilometers deep and subtend a 45 degree arc. The segment P_K's are for a hypothetical terminal ground defense site. With the site template parameters set, we now turn our attention to the computer program to run the basic model.

The Basic Model

The computer program for the basic model is the TMPSA program. A copy of the program is in Appendix A. All variables are identified in this program listing.

The results for the basic model are shown in Appendix C. The most important result is that total exposure equals 63.99.

The Control Model

The control model represents the no-feedback case. The other models developed will be compared to the results of this model.

There are only two changes to the input required. The number of threat sites is increased to eleven (NSITE = 11). With the increase in sites, another location is required. Using the same technique described earlier, the random number 56865 was selected from the CRC, line 11 column 8 (Ref 2:545). Since this site is not static, a range of locations is needed. It is noted that the only variability this new threat poses in this situation is with respect to the threat offset from the flight path. Thus, the x coordinate was

taken as 56 and the y coordinate was varied from one corridor limit to the other. The program output is in Appendix C. The run results are shown in Table 2.

TABLE 2

Control Model: Total Exposure Table

Mobile Threat Location		Total Exposure
x	y	
56.00	27.5	67.87
56.00	30.0	80.00
56.00	32.5	80.43
56.00	35.0	79.48
56.00	37.5	80.43
56.00	40.0	80.00
56.00	42.5	67.87

Chapter III The Automatic Mission

Introduction

In this chapter, results are presented for the case where the TMPSA program was used to determine the flight path through the threats. This is the opposite extreme situation from Chapter two. Thus, in this chapter we assume perfect knowledge of threat locations in determining the aircraft flight path. The previous chapter assumed no knowledge of threat locations.

The TMPSA program includes the capability to be used as the flight path generator. The procedures for determining the exposure were the same as used in Chapter two. The difference in using the full power of TMPSA is the ability of the program to choose among alternate routes. This is accomplished by the program through a change of the input data.

The procedure requires input of the aircraft speed (VMN) required to reach the finish point on schedule. It is important to note that VMN is the constant x component of the velocity. Next, the maximum speed (VMX) for the aircraft is input. This implies that the aircraft cannot deviate from the centerline of the corridor by an angle greater than:

$$\psi = \text{Arccos}\left(\frac{VMN}{VMX}\right)$$

If a deviation of greater than ψ is allowed, VMN would no longer suffice as the x direction velocity component. The third bit of information required is the awareness radius (R).

This is the maximum distance at which the aircraft becomes aware of the threat. Figure 6 shows the resulting geometry (Ref 19:4).

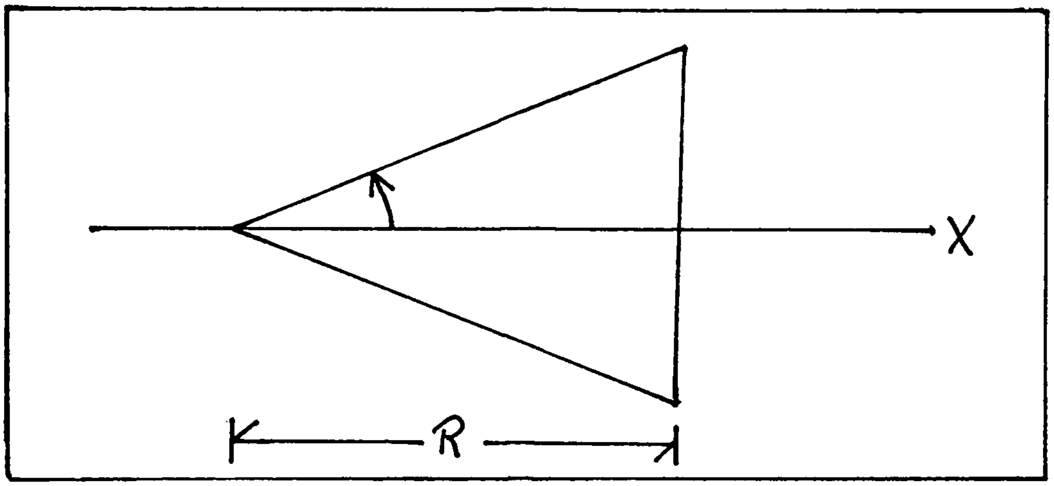

Fig. 6. TMPSA Wedge Geometry (1)

The next step was to divide ψ into a number of parts (J) which is input. This results in 2J + 1 rays emanating from the current aircraft location (x, y). Each ray is then subdivided into a number of steps x_1, x_2, ..., x_N. (Ref 19:9). Figure 7 illustrates this situation.

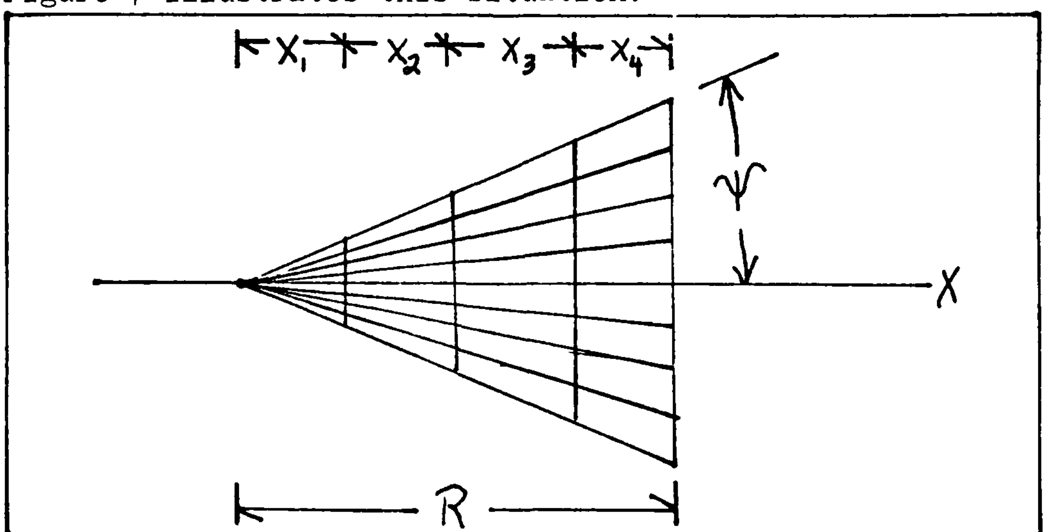

Fig. 7. TMPSA Wedge Geometry (2)

The TMPSA program computes the exposure along each of the 2J + 1 rays through N steps, then selects the ray with the minimum exposure. The aircraft position is moved one step along that ray and the position and exposure are updated. Then the process is repeated (Ref 19:9).

The program makes two tests to keep the aircraft within specified limits. The corridor test ensures that the aircraft does not stray beyond the corridor limits. This is accomplished by eliminating any ray from consideration which would cause the aircraft to make its next step out of the corridor. The second test is the "wedge" test to ensure that the aircraft arrives over the finish point. This is accomplished by determining the maximum lateral distance the aircraft can be from the centerline and still reach the final point assuming flight at maximum speed. For the wedge test, note the geometry in Figure 8. If the aircraft is allowed to travel into the shaded area, it cannot maintain a constant x direction velocity and reach XF on schedule. Therefore, any ray causing the aircraft to step out of the wedge is eliminated.

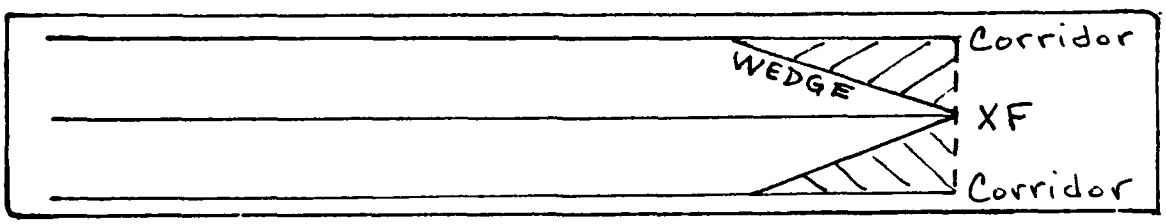

Fig. 8. TMPSA Terminal Wedge Geometry

Automatic Input

Two cases were considered for perfect knowledge. In the

first case, the awareness radius is set to 25 kilometers, the maximum number of steps the program can hold. This was done so that each step would equal one kilometer, thus the output would be comparable with the control model output. In the second case, the awareness radius was set at 100 kilometers, thus allowing the aircraft the capability of selecting its path based on knowledge of all threats in this scenario. This results in a four kilometer step size. The maximum speed allowed in both cases was 390 knots (722 km/hr) (Ref 18). The number of rays considered was eleven. This is the maximum capability of the TMPSA program.

Automatic Run Results

The run results for the two cases of the automatic mission are shown in Table 3.

TABLE 3

Automatic Model: Total Exposure

Mobile Threat Location x	y	Case 1 1 KM Steps	Case 2 4 KM Steps	d
56.0	27.5	42.16	67.31	25.15
56.0	30.0	48.17	78.29	30.12
56.0	32.5	50.01	62.27	12.26
56.0	35.0	50.36	62.67	11.91
56.0	37.5	53.98	69.20	15.22
56.0	40.0	40.41	64.78	24.37
56.0	42.5	36.44	60.38	23.94

Note that the results for the two cases described above follow a similar trend. A paired t-test indicates that there is a

statistical difference between the two results at the 95 percent confidence level. The column labeled d is the difference between the second case and the first. Let $D = \frac{1}{n}\sum_{i}^{n} d_i$, and compute s_d^2, the sample variance.

$$s_d^2 = \frac{\sum_i^n (d_i)^2 - \frac{(\sum_i^n d_i)^2}{n}}{n - 1}$$

where, n = the number of d_i's. For the data in Table 4, we obtain: $D = 20.42$, $s_d^2 = 51.75$, $n = 7$

The null hypothesis is that the mean of the deviations (d) is zero. The test statistic is:

$$t_o = D \Big/ \sqrt{s_d^2/n} = 7.510$$

The tabulated t for a two-tailed test with 95 percent confidence and six (ie. n - 1) degrees of freedom is, t = 2.365 (Ref 9:477). The rejection criteria for this test is, reject if $|t_o| > t$ (Ref 9:267,269). Clearly, the hypothesis is rejected. Since step size causes a significant difference in exposure, the step size will be held constant throughout the experiment, if possible.

The above discussion concludes this section on perfect knowledge of the threat locations. In the next section, exposure is examined when perfect knowledge is not available, for example, due to sensor limitations, but an automatic flight path generator is used.

Uncertainty of Location

Due to the complexity of the geometry between the threat

sites, their templates, and the aircraft, the problem of uncertainty is resolved using simulation. The measurement of range and azimuth is simulated by adding zero-mean, normally distributed noise terms to the actual range and azimuth. The procedure for accomplishing this is described below. The algorithm is included as part of the TMPSA program in Appendix B.

The algorithm used by the program to accomplish the randomization of the site location with respect to the aircraft is based on changing the statistical scale. The algorithm begins with selection of a series of random numbers, R_j, from a uniform distribution between zero and one. A unit variance is generated by:

$$N_A = \sum_{j=1}^{12} R_j - 6$$

The result approximates a sample drawn from a truncated normal (0,1) distribution (Ref 12:90-95). Multiplying the sample by the standard deviation yields a noise term In effect, the multiplication spreads the normal distribution. The noisy azimuth measurement becomes:

$$\alpha_k' = \alpha_k + \sigma_\alpha N_A$$

where, α_k' is the noisy azimuth measurement to the kth site, α_k is the actual azimuth measurement to the kth site, and σ_α is the standard deviation of the azimuth measurement (Ref 20:6). The addition results in the normal distribution being moved from zero to the actual azimuth.

The noisy range measurement is determined by:

$$r_k' = r_k + r_k \sigma_r N_R$$

where, r_k' is the noisy range to the k^{th} site, r_k is the actual range to the k^{th} site, σ_r is the standard deviation of the normalized range measurement and N_R is a normally distributed random variable with unit variance generated the same way as N_A (Ref 20:7).

The location from the aircraft for site k is determined by the relationships above, ie.

$$x_k' = x_n + r_k' \cos \alpha_k'$$

$$y_k' = y_n + r_k' \sin \alpha_k'$$

where (x_n, y_n) is the aircraft location. This computation results in an estimate of the site location for one measurement.

Clearly, if a large number of measurements were taken and averaged, the limiting condition would be to have perfect knowledge of threat locations. In actual fact, time is available to take only a finite number of measurements. The question then is how many measurements can a processor handle in the time it takes to make each step. The procedure to estimate this was to define the processing time per measurement, and the distance per step and speed in the x direction. Dividing the distance by the speed and then dividing this result by the processing rate will yield the number of measurements per step.

The last problem to be solved is the determination of the number of simulation runs required. Since there is

uncertainty as to the standard deviation of the exposure for each run and the feasible range of the possible standard deviation, a formulation for the number of runs is:

$$n = \frac{(Z_{\alpha/2})^2 \sigma^2}{(\sigma/b)^2}$$

where, n is the number of samples, $Z_{\alpha/2}$ is the risk to be taken (ie. $Z_{\alpha/2}$ is the two-tailed standard normal statistic for the level selected), and $\pm \frac{\sigma}{b}$ is the interval about the mean in which the sample value will lie between 100 $(1-\alpha)$ percent of the time (Ref 16:188).

This ends the discussion of the formulation for the case with uncertain threat location. In the next section, actual parameters to be used are presented.

Uncertain Location Inputs

The first inputs necessary for the simulation are the standard deviation of the range and azimuth (σ_r and σ_α). In an earlier study using TMPSA it was determined that exposure increased greatly when $\sigma_r \geq 0.15$ and $\sigma_\alpha \geq 5$ degrees (Ref 20:13). These critical values will be used. An argument will be offered later that sensitivity analysis of these parameters is unnecessary.

The next input parameter needed is the number of measurements per step. Assume one second is required for each measurement. The aircraft in this model is traveling at 648 kilometers per hour at one kilometer per step in the x direction. Therefore, the processor is averaging more than five measurements per step. Obviously, the number of

measurements per time is sensitive. The time of one second per measurement is slow for modern processors, and is therefore, a conservative assumption (Ref 8:E-3)(Ref 15:9). It is further noted that for ten or more measurements the exposure rate converges rapidly to a low value (Ref 20:13-16). It is by this same set of circumstances that it was shown that the exposure becomes fairly constant for a suitably large number of measurements (Ref 20:13-16). Thus sensitivity analysis of σ_r and σ_α is unnecessary.

The formula for determing the number of runs indicates that 16 runs would be needed (rounded up from 15.37) to have a 95 percent probability that the average exposure over those runs will lie within the interval $\mu \pm \frac{\sigma}{b}$ where μ is the true average exposure, and b = 2. Since this is a very broad range, these initial runs are used to determine a sample standard deviation (s). This statistic and the t statistic are then used to derive another number of runs. In this case, the number of runs is determined by:

$$n = \frac{t^2 s^2}{d^2}$$

where, t is the tabulated t value for the desired confidence level (α), and the degrees of freedom of the sample runs, s^2 is the estimate of the variance obtained from the sample runs and d is the half-width of the confidence interval specified (Ref 16:189).

Run Results with Uncertainty

The results of the first sixteen runs are shown in

Table 4. The cumulative exposure and standard deviation are indicated.

TABLE 4

Average Exposure: 16 Runs

Run	Total Exposure	Cumulative Average Exposure	Standard Deviation
1	55.07	55.07	----
2	55.61	55.34	.382
3	60.38	57.02	2.922
4	56.94	57.00	2.386
5	54.62	56.52	2.325
6	54.08	56.12	2.306
7	55.48	56.02	2.119
8	58.57	56.34	2.158
9	54.89	56.18	2.076
10	57.51	56.32	1.002
11	58.32	56.50	1.993
12	55.36	56.40	1.928
13	54.80	56.28	1.899
14	55.72	56.24	1.831
15	55.46	56.19	1.776
16	58.18	56.31	1.786

Clearly, the average exposure is converging to a value around 56. To compute the average exposure within ± 0.5, however, with a 90 percent confidence requires n runs.

$$n = \frac{t^2 s^2}{d^2}$$

The t statistic is the t value for 15 degrees of freedom and $\alpha = 0.1$. This equals 1.753 (Ref 9:477). From Table 4,

s equals 1.786, And d is the interval of ±0.5. Therefore,

$$n = \frac{(1.753)^2(1.786)^2}{(.5)^2} = 39.2$$

By making 40 runs, it can be stated with a 90 percent confidence that the actual average exposure lies between plus and minus 0.5 of the computed value. Table 5 shows the average results for each case of 40 runs. The computer output is in Appendix C.

TABLE 5

Uncertain Model: Total Exposure Table

Mobile Threat Location x	Mobile Threat Location y	Average Exposure	Standard Deviation
56.0	27.5	44.0	3.7
56.0	30.0	52.5	4.2
56.0	32.5	51.8	3.5
56.0	35.0	52.3	3.7
56.0	37.5	56.0	3.7
56.0	40.0	44.4	3.4
56.0	42.5	38.8	3.7

This completes the discussion and data collection for the automatic model. In the next chapter, some of the complexities of the human and machine interactions used to model the manual mission are introduced into the model.

Chapter IV The Manual Mission

The manual mission involves more specific modeling of the human factor in the experiment. First, an overview of human reaction time theory is presented. Next, current aircrew interactions are described, and the complexities of these interactions are discussed. From this a simplified aircrew reaction model is developed. Finally, this model is used to modify the TMPSA input data. The revised input is run using TMPSA, as shown in Appendix B, and the output derived will parallel the results of Chapters two and three.

Overview of Human Reaction Time Theory

There are currently two principal theories to describe human response times, the additive component theory and the variable criterion theory (Ref 6:431).

The older, additive component theory traces its origins to the experiments of Donders during the mid 1800's (Ref 14:2). One of the most recent applications of this theory is the method of convolution (Ref 10:3-4). Using this method, Kohfeld and Nullmeyer identified three component stages of response time; sensory-detection, stimulus identification, and response execution (Ref 10:11). The main contention of this theory is that these stages occur consecutively rather than simultaneously. Thus, the components are additive in nature.

The variable criterion theory was first proposed by

Grice in 1968 (Ref 14:4). In its present form, the theory postulates that "response evocation will result when the combined strength of the (sensory) processes satisfies a decision criterion." (Ref 6:431). For a simple reaction time experiment, sensory growth occurs with respect to time in a negative exponential fashion until it reaches the criterion. The criterion is described as a normal distributed random variable. At the point where excitatory strength reaches this momentary criterion level, a response occurs (Ref 14:8). A basic premise of this theory is that reaction time need not and should not be broken down into component parts to be described. This theory holds that the components vary from completely overlapping to no overlapping and therefore cannot be summed accurately.

Irrespective of the theory used, there are a number of factors which affect reaction time. The most important of these factors are noted as follows:

a. The sense used.

b. The characteristics of the signal.

c. The complexity of the signal.

d. The signal rate.

e. Whether or not anticipatory information is provided.

f. The response characteristics of the body member used. (Ref 11:228).

These factors will be used to build the simple aircrew response model.

First, however, a description of a current bomber

aircrew interaction is presented. This relies heavily on the author's seven years of experience as a B-52 Electronic Warfare Officer (EWO).

Description of Current Bomber Crew Procedure

The simplest engagement is the one-on-one situation. In this case, the engagement begins for the aircrew when any crewmember detects a threat. Under normal circumstances, the EWO will detect a radar directed threat first on ECM receivers. Information about the relative location of the threat is passed to the rest of the crew. If the threat is immediate, the pilot will attempt to maneuver the aircraft to avoid being hit while the EWO applies electronic self-protection measures. If more time is available, the navigator may become involved. Based on the relative location transmitted by the EWO, the navigator will attempt to identify the threat from among the known enemy threats in the area. Then he will direct the pilot to follow a course which enables the bomber to avoid the lethal envelope of the threat.

Although the procedure is fairly simple to describe, the possible interactions result in a virtually infinite number of possible aircraft maneuvers. Variables include the time it takes the EWO to detect and identify the threat, the time it takes him to transmit this information to the rest of the crew, the time it takes for the pilot to "detect" the EWO's message, and finally, the specific maneuver the pilot chooses to make. These variables do not even consider the

time required to react if the navigator is involved in the process. In the next section, a much simpler model is developed. Its purpose is to include the man in the loop of the TMPSA program.

Simplified Crew Procedure

To simplify the crew reaction model, the following scenario is used. Aircraft sensors receive the threat radar emissions. This information is processed using an algorithm like TMPSA. The output is then passed in the form of a digital readout to the pilot. The pilot is prompted to respond by observing the heading readout. He responds by making an input via the aircraft controls. Then, the aircraft mechanical response follows.

As noted earlier, the hardware sensing-processing time is assumed to be one second (see Chapter three). The crewmember response time to a visual prompt is on the order of 0.2 second (Ref 11:229) (Ref 7:305,307). However, for tasks such as the simple response outlined above, the maximum rate of response is two to three per second (Ref 11:231). These are mean times drawn from the probability distributions for reactions as described earlier in this chapter. They are sufficient for the purpose of this study. Assuming a conservative two responses per second reaction rate, the pilot can keep pace with the sensor-processor, except there will be a half second lag.

Another lag occurs when the mechanical input of the

pilot is translated into aircraft movement. The first part is the aircraft response time. The second part is the time it takes the aircraft to complete the turn. The mechanical response time is considered a constant for like aircraft while the turn time is based on the aircraft turn rate and angle through which the aircraft must turn. Continuing use of the B-52 data, the mechanical response time is on the order of a half second (Ref 4). The time required to complete a turn is a function of the angle of bank, the altitude, and the speed of the aircraft.

Another way to view the simplified crew procedure is to consider actions along a time line (see Figure 9). The action starts with the sensor picking up a threat signal. After one second, a heading readout is displayed for the pilot. The pilot reaction time is a half second. Finally, it takes a half second for the mechanical translation of the pilot's input to start the aircraft turning and a certain amount of time to complete the required turn.

If the readout changes during this time, it is assumed the pilot would be too preoccupied to notice. In that case, the next cycle begins when the pilot rolls out on the first indicated heading. Thus, the delay is actually only the time required for the pilot and aircraft to react to a new heading. During that reaction, another heading is being processed. Figure 9 shows these simultaneous actions.

Manual Model Inputs

To make the results of the manual model comparable with

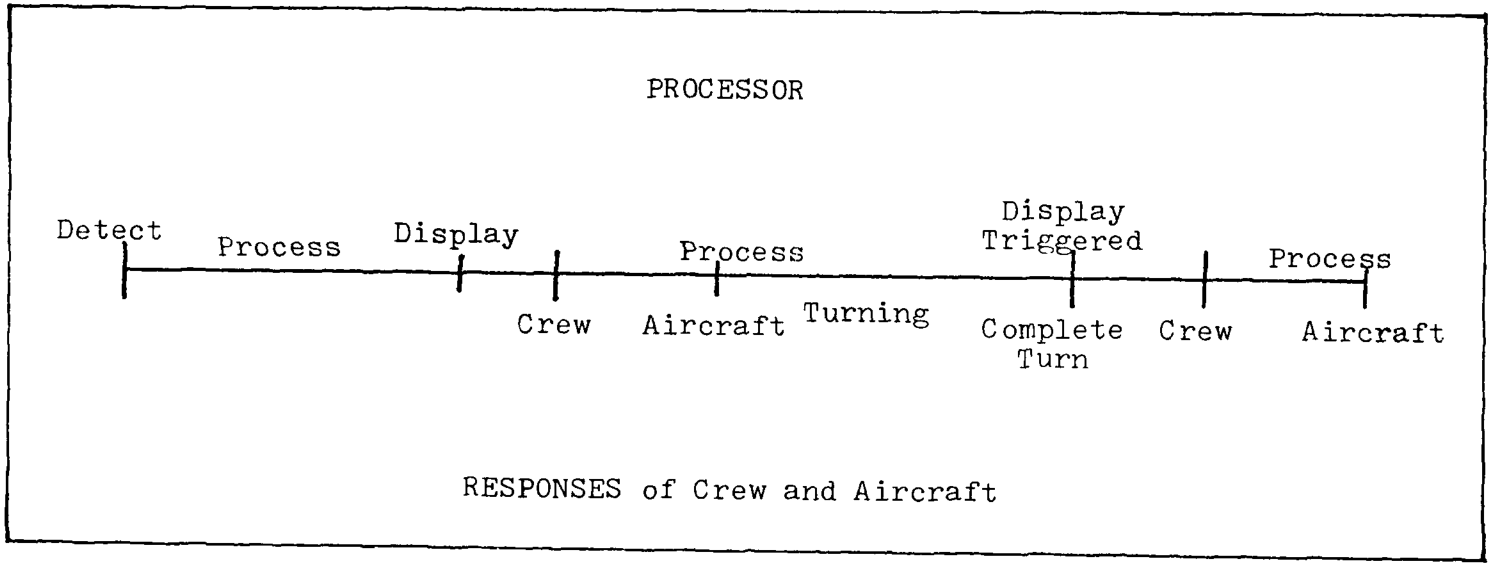

Fig. 9. Penetrator Response Timeline

the control model, it is necessary to minimize the changes to the input data. The method used is to determine how quickly the man-machine system can react. Assuming that the awareness radius (R in the model) remains 25 km, the size of each step (DX), the number of steps in the awareness radius (NSEG), and the number of measurements for each reaction (NM) can be computed.

Figure 9 shows how the event chain occurs. Figure 10 below portrays this event chain as a cycle.

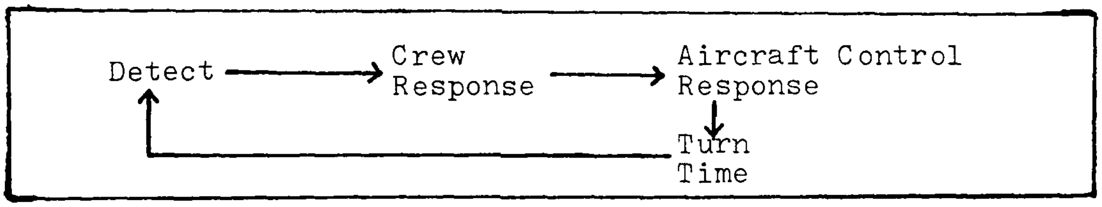

Fig. 10. Penetrator Response Cycle

In the previous section, the crew response time was assumed to be a half second, and aircraft mechanical response time was stated to be a half second. The turn time must be determined.

As noted earlier, the airspeed, altitude, and bank angle of the aircraft determine the level rate of turn. In this model, the altitude and airspeed are constant. The altitude is about 1,000 ft, and the airspeed ranges from 350 knots to 390 knots. The maximum turn ψ for this scenario is computed by:

$$\frac{\text{minimum speed}}{\text{maximum speed}} = \cos \psi$$

Using the airspeeds above, ψ = 26.2 degrees.

The only variable left is the angle of bank. At low

altitude, the normal angle of bank used by the B-52 is 12 degrees to 15 degrees. However, a turn of up to 30 degrees is possible, but hazardous (Ref 18). The fastest rate of turn for 30 degrees angle of bank is at the slower airspeed (ie. 350 knots). The maximum turn rate is 1.8 degrees per second at 350 knots, 1,000 ft altitude, and 30 degrees angle of bank (Ref 18). Therefore, to complete the 26.2 degree turn, the shortest time is 14.5 seconds. This represents the minimum time for the maximum turn. It is possible with the TMPSA program for the aircraft to turn from a maximum heading of $+\Psi$ to a maximum heading of $-\Psi$, thus covering 2Ψ degrees. Since this represents a rather violent maneuver, it is assumed that extraordinary measures such as this would be accomplished by exceeding the assumed parameters of the scenario. For this reason the 14.5 second turn time will be used. Also, any smaller turn can be made in this time using a shallower, and thus safer angle of bank. Therefore, this is used as the turn time constant.

The total response cycle is a half second for crew response, half a second for aircraft mechanical response, and 14.5 seconds for completing the maneuver. The sum of these is 15.5 seconds.

The size of each step is a function of the airspeed (in the x direction), and the total response time. That is:

$$\frac{648 \text{ km/hr}}{3{,}600 \text{ sec/hr}} \cdot \left(15.5 \ \frac{\text{sec}}{\text{response}}\right) = 2.79 \ \frac{\text{km}}{\text{response}}$$

In the TMPSA program this is DX.

Since the awareness radius (R) is kept at 25 kilometers, the number of steps (NSEG) in the awareness radius is:

$$DX = \frac{R}{NSEG} \quad \text{or} \quad 2.79 = \frac{25}{NSEG} \quad \text{and } NSEG = 9 \text{ by choosing}$$

the closest integer.

The last piece of information needed is the number of measurements per step (NM). This is the number of measurements which can be processed during each response cycle. NM is computed by:

(15.5 seconds/response)(1.00 measurments/second) =

15.5 measurements/response (round down to the nearest integer).

To summarize, the inputs for the manual mission are:

$$\begin{aligned} R &= 25 \\ NSEG &= 9 \\ NM &= 15 \end{aligned}$$

Run Results

To be comparable with the results in Chapters two and three, the TMPSA program was run through forty iterations for each position of the mobile threat. The output is in Appendix C. The results are summarized in Table 6.

TABLE 6

Manual Mission: Total Exposure Table

Mobile Threat Location x	Mobile Threat Location y	Average Exposure	Standard Deviation
56.0	27.5	34.6	4.2
56.0	30.0	46.8	4.4
56.0	32.5	44.3	3.2
56.0	35.0	44.6	3.6
56.0	37.5	48.7	3.8
56.0	40.0	39.0	3.5
56.0	42.5	30.5	3.4

Chapter V Results and Analysis

Results

In this chapter, the results of the missions described in Chapters two through four are tabulated and analyzed. Table 7 summarizes the results for all four mission types.

TABLE 7

Summary Results Table

			Exposure				
Index i	Threat y-coordinate	Control	Automatic	Uncertain		Manual	
1	27.5	67.87	42.16	44.0	3.7	34.6	4.2
2	30.0	80.00	48.17	52.5	4.2	46.8	4.4
3	32.5	80.43	50.01	51.8	3.5	44.3	3.2
4	35.0	79.48	50.36	52.3	3.7	44.6	3.6
5	37.5	80.43	53.98	56.0	3.7	48.7	3.8
6	40.0	80.00	40.41	44.4	3.4	39.0	3.5
7	42.5	67.87	36.44	38.8	3.7	30.5	3.4

The general structure of these results is intuitively appealing with the exception of the manual mission results. Figure 11 shows what one could intuitively expect to occur. As the level of feedback increases from no information on the left to much accurate information on the right, exposure decreases.

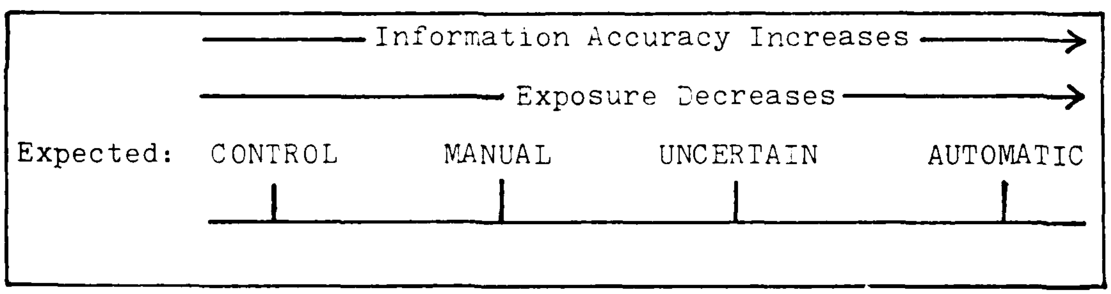

Fig. 11. Accuracy vs. Exposure Line

In the following sections, each step used to develop the final results is explained. How the changes in input affected the exposure is interpreted. Finally, comments are made to explain how much of the exposure change is attributable to the input change.

From this discussion, the reason for the counterintuitive mission results is explained. With the reason for this anomoly explained, the manual mission results are adjusted, then an analysis of the differences between the manual and control missions is accomplished to find the value of reactive maneuvers.

Control to Automatic

The only change in the input data between the control mission and automatic mission is the maximum speed. The maximum speed used for the control mission is 648 kilometers per hour. Since the minimum speed is also 648 kilometers per hour, the penetrator can only travel down the center path. This simulates no feedback to the aircrew of the status of enemy defenses. The maximum speed for the automatic mission is 722 kilometers per hour. Taken with the other input data, this situation simulates accurate and timely information reaching the crew. The crew is thus able to choose the flight path using the TMPSA algorithm to find a flight path which reduces total exposure.

The total exposure declined in absolute and relative terms as shown in Table 8.

TABLE 8

Control/Automatic Mission Differences

i	Exposure Control	Automatic	d_{1i}	Δ_{1i}
1	67.87	42.16	25.71	0.38
2	80.00	48.17	31.83	0.40
3	80.43	50.01	30.42	0.38
4	79.48	50.36	29.12	0.37
5	80.43	53.98	26.45	0.33
6	80.00	40.41	39.59	0.49
7	67.87	36.44	31.43	0.46

In Table 8, $d_{1i} = \text{Control}_i - \text{Automatic}_i$

$$\Delta_{1i} = d_{1i} \div \text{Control}_i$$

The average relative exposure difference (Δ_1) is:

$$\Delta_1 = \frac{1}{n} \sum_{i=1}^{n} \Delta_{1i} \quad \text{for all values of } i$$

For the data in Table 8, $\Delta_1 = 0.40$. The standard deviation (σ_1) is 0.06. The variance (S_d^2) is computed as detailed in Chapter three and σ_1 is the square root of S_d^2.

It would appear from the above analysis that the effect of accurate knowledge of threat locations decreases exposure by about 40 percent. The relatively wide dispersion of these results seems to indicate that the scenario itself is a factor.

Automatic to Uncertain

Two changes were made in the input data in going from the automatic mission to the uncertain mission. The first was to change the standard deviations of the range and azimuth measurements from zero to 0.15 times the actual range and 5 degrees respectively. The effect is to introduce

uncertainty into the location of the threat sites. The second change between the automatic and uncertain missions was to average a number of range and azimuth measurements of a site before a location for that site is estimated. This has the effect of reducing the measurement uncertainty by the averaging process.

The net effect of these two changes is to cause the TMPSA flight path algorithm to make choices based on less than perfect information. Table 9 shows the increase in exposure that resulted from this uncertainty. In Table 9,

$$d_{2i} = \text{Uncertain}_i - \text{Automatic}_i$$

$$\Delta_{2i} = d_{2i} \div \text{Control}_i$$

For the uncertain mission, the mean values are used.

TABLE 9

Automatic/Uncertain Mission Differences

i	Uncertain	Automatic	d_{2i}	Δ_{2i}
1	44.0	42.2	1.8	.026
2	52.5	48.2	4.3	.054
3	51.8	50.0	1.8	.022
4	52.3	50.4	1.9	.024
5	56.0	54.0	2.0	.025
6	44.4	40.4	4.0	.050
7	38.8	36.4	2.4	.035

$\Delta_2 = .034$ $\sigma_2 = .013$

The above analysis indicates that there is about a three and a half percent decrease in exposure that can be directly related to the accuracy of measurement of threat location. Again, a wide variance suggests the scenario is

a significant factor.

<u>Uncertain to Manual</u>

Two changes were made in the input data in going from the uncertain mission to the manual mission. The number of measurements of each site to establish a location was increased. The result of this change is to decrease the uncertainty in locating threats. The second input change was to decrease the number of steps in the awareness radius. Since the awareness radius was not changed, the effect is to take larger steps. As noted in Chapter four, the step size changed from one kilometer per step to about 2.8 kilometers per step.

This was not considered significant until the results of all missions were compared in Table 7. Careful consideration of the model dynamics offers a logical explanation. First, the locations of the threats are more accurately known because more measurements are being taken. Second, the increased step size is significant because it is larger than the depth of site template segments. This allows the airplane to step completely over the worst probability of kill segments without incurring a commensurate exposure penalty. Figure 12 shows how this can occur. Note that path A is a shorter path and still keeps out of the segments with large probabilities of kill.

A correction factor of 6.3, derived as shown below, was added to all of the manual mission values to establish a

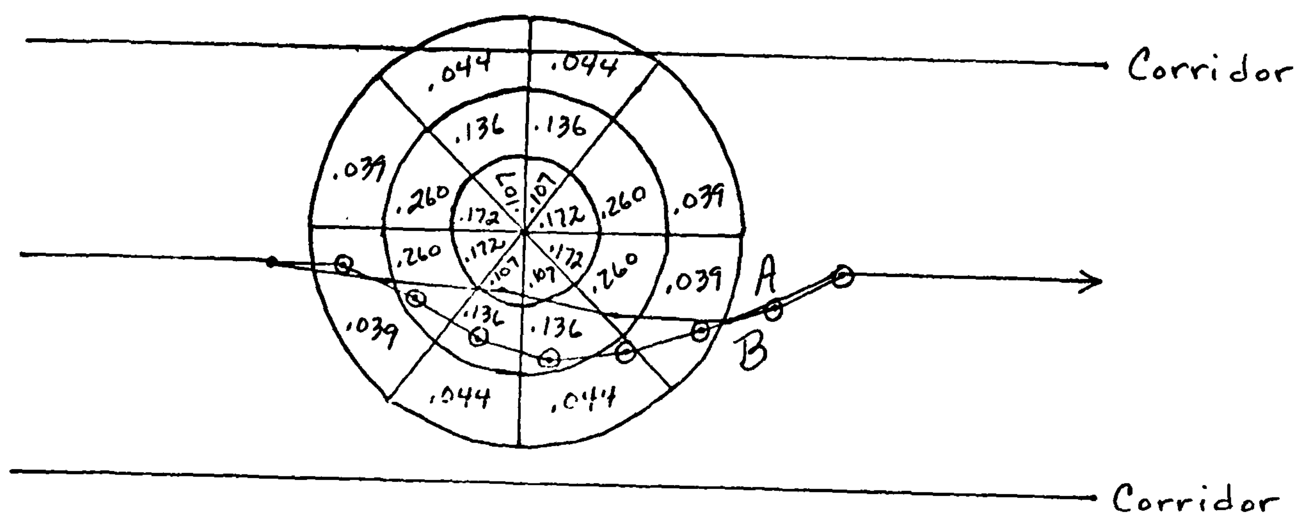

Fig. 12. Manual Step Anomaly

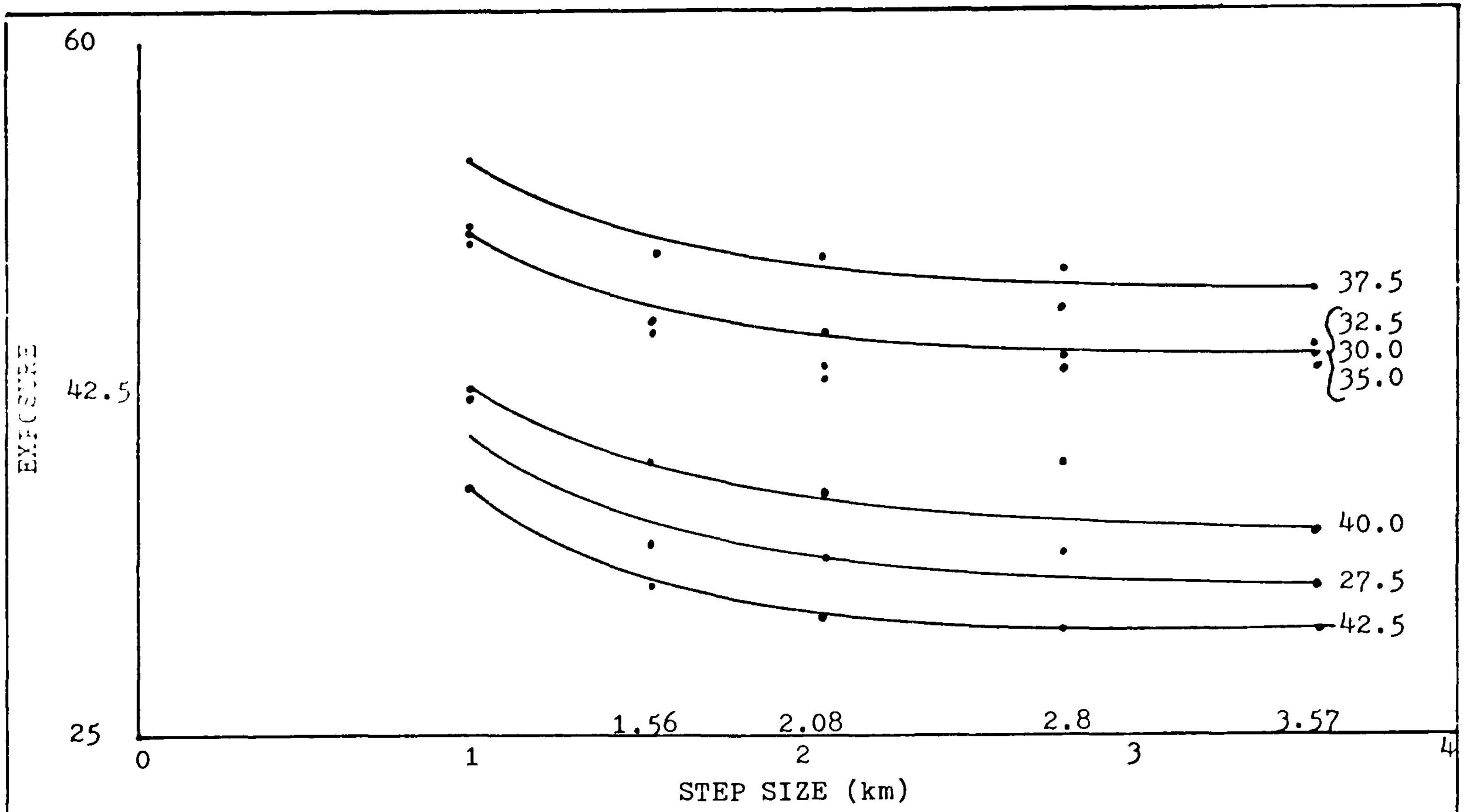

Fig. 13. Exposure Dependence on Step Size

revised manual mission exposure. This revised manual mission output is then compared with the uncertain output in the next section.

The correction factor was derived by showing the dependence of exposure to step size. To do this 40 simulations were run for each value of the mobile threat site (7) and for five step sizes. This resulted in 35 data points. The raw output is in Appendix C. Figure 13 summarizes these results. Smooth curves are drawn in for each of the seven scenarios. Although a number of data points are off the curves, none are off by more than one standard deviation. Only one curve does not connect the end points. The scenario with the eleventh threat y-coordinate at 27.5 is the only one where the exposure at a step size of one kilometer is not on the curve. This curve is based on the shape of the other six curves; and the point at one kilometer is, as noted, within one standard deviation of the raw data mean (see Appendix C).

For each scenario, the exposure is read from the curve at the 2.8 kilometer step size and subtracted from the 1.0 kilometer step size exposure value. The values are shown in Table 10. These differences (D_i) are then averaged. This average of 6.3 is the correction factor. The standard deviation is 0.5. The revised manual mission values are shown in Table 11 in the next section.

TABLE 10

Exposure Difference Due to Step Size

i	1.0 Value	2.8 Value	D_i
1	40.0	33.0	7.0
2	51.0	45.0	6.0
3	51.0	45.0	6.0
4	51.0	45.0	6.0
5	54.0	48.0	6.0
6	43.0	37.0	6.0
7	37.0	30.0	7.0

Uncertain to Revised Manual

With the step size difference accounted for, the main difference between the uncertain and manual missions is the number of measurements taken for each step. Since more measurements are taken for the manual mission, the results of this comparison should be that the revised manual exposure is lower than the uncertain. Table 11 shows the effect of increased information of threat locations.

$$d_{3i} = \text{Uncertain}_i - \text{Revised Manual}_i$$

$$\Delta_{3i} = d_{2i} \div \text{Control}_i$$

Mean values are used for the uncertain and revised manual data.

TABLE 11

Uncertain/Revised Manual Mission Differences

	Exposure			
i	Uncertain	Revised Manual	d_{3i}	Δ_{3i}
1	44.0	40.9	3.1	.046
2	52.5	53.1	-0.6	-.007
3	51.8	50.6	1.2	.015
4	52.3	50.9	1.4	.018
5	56.0	55.0	1.0	.012
6	44.4	45.3	-0.9	-.011
7	38.8	36.8	2.0	.029

$$\Delta_3 = .014 \quad \sigma_3 = .020$$

The above results indicate that increasing the accuracy of threat location information in this scenario does not significantly change exposure between the uncertain and revised manual missions. Thus, one of the three factors affecting exposure is eliminated from consideration. That is, sensors accurate to five degrees in azimuth and 15 percent in range are adequate if at least one measurement per second can be taken.

The second factor affecting exposure is the absolute accuracy of the sensors. If the accuracy of the sensors is perfect, as opposed to five degrees in azimuth and 15 percent in range uncertainty, it was shown that the exposure is reduced by about three and a half percent.

The remainder of the reduction in the total exposure is related to the ability of the aircraft to maneuver. This is the third factor affecting exposure. In the next section, the value of maneuverability is derived from a comparison of the control and revised manual missions.

Control to Revised Manual

The comparison of the control mission with the revised manual mission yields the value of reactive maneuvers. In the revised manual mission, a degree of knowledge of the defenses allows the penetrator to make decisions required to maneuver the aircraft. The two differences between the control and the revised manual mission are maneuverability and threat location knowledge. Table 12 illustrates this comparison

where:

$$d_{4i} = \text{Control}_i - \text{Revised Manual}_i$$

$$\Delta_{4i} = d_{4i} \div \text{Control}_i$$

TABLE 12

Control/Revised Manual Mission Differences

i	Exposure Control	Exposure Revised Manual	d_{4i}	Δ_{4i}
1	67.87	40.9	27.0	.40
2	80.00	53.1	26.9	.34
3	80.43	50.6	29.8	.37
4	79.48	50.9	28.6	.36
5	80.43	55.0	25.4	.32
6	80.00	45.3	34.7	.43
7	67.87	36.8	31.1	.46

$$\Delta_4 = .38 \qquad \sigma_4 = .05$$

These results indicate that the survivability increases by about 38 percent when there is adequate knowledge of threat locations and the aircraft is allowed to maneuver.

The next chapter discusses the analysis results stated above and judgements on the results are rendered.

Chapter VI Conclusions and Recommendations

The conclusions to be drawn from the above analysis must take into consideration a number of limitations discovered in the course of this research. A critique of TMPSA is followed by conclusions and some recommendations for future work in this area.

Critique of TMPSA

The goal of TMPSA is to determine how aircraft sensor measurement accuracy is related to aircraft survivability against surface-to-air weapons. The goal of this research was to use TMPSA to derive a value for reactive maneuvers. Following is a critique of the main weaknesses and strengths of TMPSA learned in its use.

The TMPSA program and supporting documentation have three categories of shortcomings. The first shortcoming is that a major claim of the TMPSA report is not factual. The second and third shortcomings are groups involving modeling shortcomings and user pitfalls. Each of these problems is presented and discussed below.

In the TMPSA report, the author claims that TMPSA uses an "algorithm to find the safest route through an arbitrary threat distribution." (Ref 20:1). In fact, while the algorithm attempts to maximize survival by minimizing exposure, it does not actually optimize. Consider how the flight path

is generated. Only a maximum of 11 rays or possible paths are examined. This immediately eliminates an infinite number of possible alternatives. The subsequent movement of the aircraft is determined by stepping in the direction which offers the lowest exposure to the awareness limit in that direction, but does not consider alternate paths which may have lower exposure.

Figure 14 shows a small sample of the possible flight paths. The solid lines are the paths considered by the TMPSA algorithm. The dotted lines are alternate possible paths. The numbers at each node are the exposure for that node and the letters identify the node.

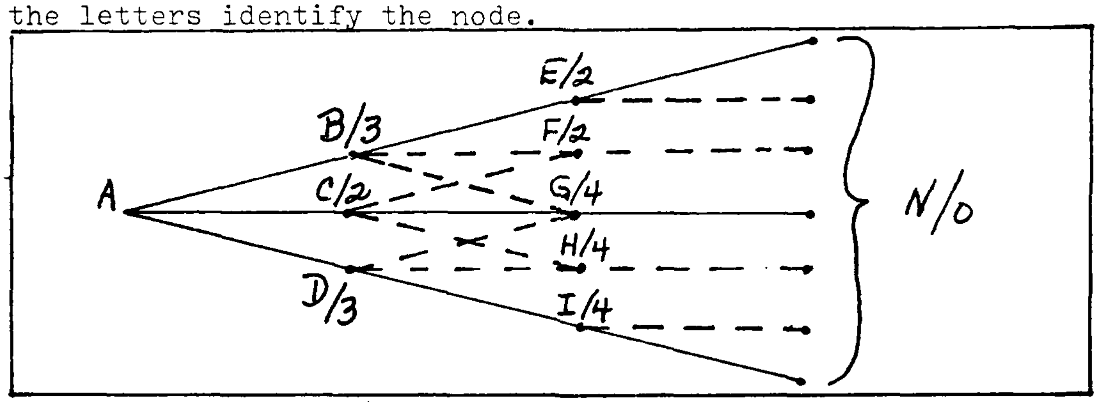

Fig. 14. Example of Flight Paths

In this example, the choices of flight paths available to TMPSA when the aircraft is at A are ABE, ACG, and ADI. The total exposure over the length of each of these flight paths is five, six, and seven respectively. The program would step to B. From B the available paths are BEN, BFN, and BGN where N represents all seven of the following nodes which are assumed to cause no exposure. They also could be viewed as all N points having equal exposure. The exposure for the paths

from B are five, five, and seven respectively. Observe, however, that if path ABEN or ABFN (total exposure equals five) are compared with ACFN, the ACFN path is safer with a total exposure of only four. Thus, TMPSA does not choose the optimum path. Although the program could be revised to accomplish the above task, the number of possible paths to be summed grows exponentially with the number of rays and the number of steps in the awareness radius. Therefore, this is not a practical solution for the usual situation being modeled.

The model has four additional shortcomings which have been grouped together as modeling shortcomings. Two of these shortcomings are related. They are lack of consideration of terrain and lack of consideration of cultural features. The factors of use of terrain and avoidance of cultural features are used extensively by operations planners to determine safe penetration routes. Terrain is used by the penetrator as cover. The penetrator will seek a flight path which causes terrain to be between the aircraft and the enemy fire control radar. Cultural features such as roads and cities are avoided by the penetrator as a way of avoiding contact with the enemy. Although not critical to the overall model, these two shortcomings reduce the credibility of the output.

The third shortcoming in this group involves the construction of the threat site templates. The only documentation of the values used in the construction of the site template used in the TMPSA study report is a parenthetical phrase

that the probabilities of kill and lethal radius were those used in a large scale simulation study (Ref 20:8). How the site templates are constructed is crucial to the model because they play a key role in determining exposure. To be able to judge the credibility of the output, the method used to generate the site templates is essential.

The last shortcoming of this type concerns where the aircraft is allowed to fly in the corridor. The aircraft has a constant velocity component along the attack axis. This is not realistic. Although the penetrator can maneuver sharply and sustain higher airspeeds to get back on time, in reality, in TMPSA it is incapable of such maneuvers because of the constant velocity component. An example illustrates this problem. Consider the problem in Figure 15.

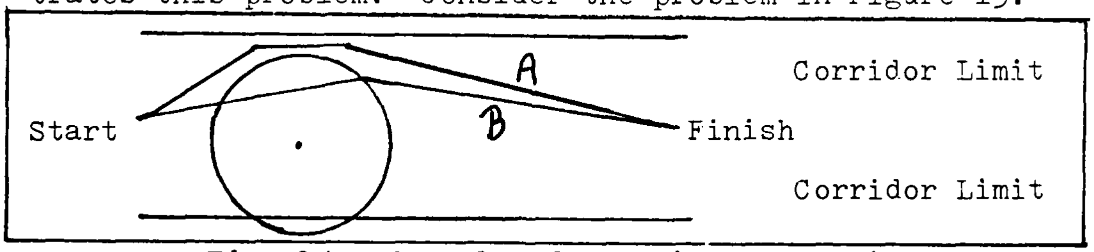

Fig. 15. Example of Velocity Constraint

In this figure, path A is longer, but at a higher sustained velocity the Finish point can be reached at the same time as the path B penetrator. The main difference is that the path A axis velocity component is allowed to vary. This is another crucial element in the total exposure computation which raises questions about the credibility of the model.

The last group of shortcomings are user pitfalls which the analyst must keep in mind when developing the input for

the model. First, the model does not explicitly include physical time and space limitations for crew reaction and aircraft motion. Turns are instantaneous at each step.

Second, a constant altitude is assumed for the penetrator. Although the program can be revised relatively easily to accomplish three dimensional motion for the penetrator, the threat site templates would also require development in three dimensions and the lack of terrain consideration would grow in importance.

Third, the model literature does not explicitly mention threats outside of the corridor limits. In this research experiment with the model, it was found that the exposure declined when external threats were introduced. The reason deduced for this anomaly was that without the exterior threats, the penetrator would track to the edge of the corridor. Because there were no threats outside the corridor, those rays would have the lowest total exposure and the penetrator would thus remain along the corridor edge.

The last pitfall concerns the data input used by the authors of TMPSA. Although they studied the effects on exposure of accuracy of sensors by range and azimuth <u>separately</u>, they produced no comments on the combined effects on exposure of range and azimuth inaccuracies <u>together</u>.

Having mentioned nine specific criticisms of TMPSA, let us now turn to the positive aspects of TMPSA. The model has three good points. Within the context of the purpose of the model, these points are the concept, model flexibility, and

intuitively appealing results.

The basic concept of the model is to investigate all of the various possible paths within the awareness radius of the penetrator, then choose the safest path. Due primarily to computer hardware and time limitations, it is not practical to investigate each and every path. Use of the computer also requires use of non-continuous probability of kill distributions for the threat site templates and the stepping of the aircraft flight path. Althouth this is artificial, the problem can be resolved by decreasing the template segment sizes and the step size of the aircraft. Again, computer hardware and time limitations restrict the resolution that can be attained. However, these input parameters can be used to control the model to a large degree.

It is through judicious data input that the model derives its flexibility. By correct selection of the input, all of the shortcomings of user pitfalls can be overcome. Also, if a proper analysis is done, the threat template can offer a true representation of a certain type of surface-to-air threat verses a certain type of aircraft. Thus, by carefully planned input, the output can be reasonable.

In using this program, it was found that the output agreed with this author's intuition. The paths selected matched closely those an operational planner might select under the same circumstances. This was achieved only when the input data was true to the scenario. In every instance where the results did not agree with intuition an error was

found in the input data.

Conclusions

This model does not portray many of the factors involved in a penetration model. Examples of items not modeled are terrain and cultural features. But the purpose of the model is not to attempt to model all the nuances of a penetration. The goal of TMPSA, as stated in the beginning, is to determine how aircraft sensor measurement accuracy is related to aircraft survivability. The purpose of this research is to use this model to examine how maneuverability affects survivability.

The analysis in Chapter five shows that the effects of maneuverability and accuracy of threat location knowledge are intertwined. From the above discussion and analysis in Chapter five, it is concluded that the TMPSA model is adequate for studying the effects of sensor accuracy and aircraft maneuverability on exposure if the input is properly prepared. However, for the reasons listed below, the model output cannot be used to establish ratio relationships among the various input variables, specifically the accuracy and maneuverability input variables.

There are two reasons for the above assertion. First, the aircraft travels through the threat array by large steps and the threats are represented as segmented probabilities of kill where the segments are relatively large. These discontinuities alone are enough to destroy the ratio relations.

Second, the model does not optimize survival. For this reason, there is no point from which to measure the lowest exposure. In fact, some runs of the program yield lower exposure with inaccurate measurements than runs which have no measurement inaccuracies!

With these caveats in mind, it can be said that the results are comparable on an order-of-magnitude scale. That is, if one set of runs results in twice the exposure of another set of runs, it is safe to say that the second set of conditions will yield a safer penetration profile than the first set of conditions. It would probably be erroneous, however, to assume the second conditions are twice as safe as the first.

From the above statement, it is inferred that the goal of relating sensor measurement accuracy and maneuverability to aircraft survivability is accomplished in a macroscopic sense. However, a clear mathematical relationship between sensor measurement accuracy and aircraft maneuverability, and aircraft survivability derived from this model is not supportable.

Having concluded that the results above are insufficient, what avenues are available to improve this rough procedure?

Recommendations

One recommendation was noted above; that is to increase resolution of the model by decreasing the step size of the

aircraft and decreasing the size of the threat template segments. Another recommendation is to expand to three dimensions. Each of these procedures increases the degree of reality being modeled. They also increase the computer running time significantly.

Two other possible approaches to this problem of quantifying reactive maneuvers are suggested. One is to try to follow every possible discrete flight path from the awareness radius limit back to the present aircraft position, one step at a time. Using a dynamic programming algorithm, all but the smallest exposure branch for each node is eliminated until the present position is reached. Then a step is taken on the last branch. Returning to Figure 14 and the example above, the technique would work as follows. In this example, the awareness radius is two and the step size is one. To node B from nodes E, F, and G, the smallest exposure is two from E and F, so G is eliminated. To node C from nodes F, G, and H, all but node F are eliminated. To node D, all three nodes G, H, and I remain possible (all equal four). To node A, the total exposure from node B is five (two plus three at B). To node A from C, the total exposure is four. And, from node D, the total exposure at node A is seven. Eliminating all but the smallest, yields the optimum flight path.

The second approach would be to rewrite the TMPSA program in terms of a computer simulation language. With TMPSA written in a simulation language, a large number of runs could be efficiently run. The mean total exposure can be determined with a tighter distribution about the mean when

more runs are made. The result would be that the analyst could have more confidence in evaluating the interaction between maneuverability and sensor accuracy on exposure.

The last recommendation is to make a change in the input to allow study of different degrees of maneuverability. In the context of TMPSA, increasing the maximum speed results in increased maneuverability. In this regard, it would be better to include some physical limits on the ability of the aircraft to turn. Even the best aircraft in the world cannot turn on a point.

To this author, the most promising direction for future work in this area is to combine the last suggestion above with the dynamic programming recommendation. It would be relatively simple to revise TMPSA with these two changes. Then a three dimensional matrix of data points relating scenario, maneuverability, and sensor accuracy could be built and the interactions of these factors analyzed. From this, a true independent value for reactive maneuvers might be developed.

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Appendix A

FORTRAN Code Listing of the TMPSA Program

```
      PROGRAM OP[illegible]TH2(INPUT,OUTPUT,TA[illegible]=[illegible]   [illegible]=OUTPUT)
******** [illegible]
*PROGRAM TO COMPUTE OPTIMUM
*PATH BETWEEN 2 CHECKPOINTS
**** [illegible]
*MULTIPLE TYPE [illegible]
*
*MAX LIM[illegible] [illegible] RAYS--
*     RAYS=11
*     STEPS=2[illegible]
*     SITES=1
*     SITE TYPES=2
*     RINGS/SITE TYPE =1
*     SECT[illegible]S/SITE TYPE=1[illegible]
*
*SUBSCRIPTS--
*     I=STEPS
*     J=RAYS
*     K=SITE TYPES
*     L=SITES
**** [illegible]
*
      COM[illegible] [illegible]Y ,P[illegible]I(1 ),P[illegible]J(11),PKTJ(11)
      COM[illegible],[illegible](2 ),[illegible](2 ),[illegible](2 ),PK,PKT[illegible](1 ,2,2 ),
     1           [illegible]L(2 ), H[illegible],PI,KY
      DIM[illegible] XP(1  ),YS(1  ),SX(1  ),SY(1  ),ITYP(1  ),[illegible](11),
     1           KK(1  ),[illegible]YY(1  ),SYY(1  )
      DIMENSION [illegible](2 ),[illegible](1  ),ITP(2 ),KKK(1  )
      DIMENSION [illegible]PHSL(2  ),[illegible](1  ),ALPH[illegible](1  ),AD(1  ),[illegible](1  )

      PI=3.1415[illegible]

*CARD INPUT[illegible]

*NO. ANGLES,STEPS,SITES,SITE TYPES,NO. OF MEASUREMENTS
      PER SITE, STANDARD DEVIATION OF RANGE & AZIMUTH
      IND=1
      RATIO=1.
10    READ 5,1[illegible])JSLICE,NSEG,NSITE,NTYPS,N[illegible],SIGMAR,SIGMAD
      WRITE (6,41[illegible])JSLI[illegible],NSEG,NSITE,NTYPS,N[illegible],SIGMAR,SIGMAD
410[illegible] FORMAT(1H ,5I1 ,2F1 .1)

*TEST END OF FILE
      IF(EOF(5).[illegible].)GO TO [illegible]

*CHECKPOINTS
      READ(5,42 )XT,YT,XF,YF
      WRITE(6,42 )XT,YT,XF,YF
420[illegible] FORMAT(1H ,4F1 .1)

*AWARENESS [illegible],M[illegible] AND VELOCITY,[illegible] WIDTH
      READ(5,1[illegible] )[illegible],V[illegible],MAX,[illegible]
      WRITE (6, 2[illegible])[illegible],V[illegible],[illegible]
```

```
*SITE DA ---
*NO. RI ,S  ,I   ,EXP
      DO 2  K=1, TYP
        R  D( ,1    )  (K). (K),  (K),IT (K)
        N  ( K)=N    (K)/
      WRI  ( , 1  )   (K), (K),  (K), (K), (K)
20    CONT NU

*SITE PK DATA
      DO 3  K= , TYPS
        M =N   (K)
        N =NS  (K)
          D( , ) ((P  ( , , K), =1, ), =1, )
      WR   ( , 2 ) ((PK  ( ,N,K), = , ), =1, )
30    CO

*SITE  D    ,TYP
50    D    L=1,
           ( ,1   ) X(L), Y(L), TYP(L)
      WRIT (6,    ) X(L), Y(L),  TYP(L)
400   FO  (1H  , F  . , )
60    CONTINUE

*END CARD INPUT

*INITIALIZATION
65    NRAYS=JSLI E+1
      CP1=SECOND(CP)
      PSI= .
      DPSI= .
      PSI N= .
      PKTO = .
      DFLWN= .
      TEMP=NSEG
      DX=  /TEMP
      TEMP=V  /V
      IF(T  P.GT.1. )TEMP= .
      PSI=  (S(T MP)
      PSI=I T(PS      .+. ) /   .
      W IT (6,  )PSI
701   FORMAT(  H PSI=,F  . )
      TEMP=JSL  
      DPSI=( .  PSI)/T  P
      TEMP=  G
      CONST=     /(  P  AN)
      SIG  E=S G    PI/   .
```

```
*SET-UP ARRAY FLOATING
*SITE NO. TO SITE TYPE
      DO    L=1,NSITE
        KK(L)=
        DO 7   K=1,NTYPS
          KK(L)=KK(L)+1
          IF(ITYP(L).EQ.ITP(K))GO TO [illegible]
70      CONTINUE
****[illegible]
        LL=L
      WRITE (6,[illegible])LL,ITYP(LL),(ITP(K),K=1,NTYPS)
      STOP
80    CONTINUE

*LETHAL RADIUS
      DO    K=1,NTYPS
        RL(K)=[illegible]
90    CONTINUE


*INITIAL A/C POSITION
110   XA=XI
      YA=YI
      XT=XF
      YT=YF

*END INITIALIZATION

*PRINT INPUT SUMMARY
      WRITE(6,[illegible])XI,YI,[illegible],XF,YF,[illegible],NRAYS,NSIG,NSITE,NTYPS,[illegible]
     +SIGMAR,SIGMAD

      DO 12   K=1,NTYPS
        WRITE(6,[illegible])ITP(K),K
        MT=NRNGS(K)
        NT=[illegible](K)
        WRITE(6,22  )((PKT[illegible](M,N,K),N=1,NT),M=1,MT)
120   CONTINUE

      WRITE(6,23  )
      WRITE(6,2[illegible])(SX(L),SY(L),ITYP(L),KK(L),L=1,NSITE)
      WRITE(6,2[illegible] )

*DISTANCE--SITE TO A/C
      WRITE(6,   5)
6[illegible] FORMAT([illegible]      RL(L)      ALPHAL(L))
20[illegible] DO [illegible]  L=1,NSITE
        [illegible]=SX(L)-XA
        [illegible]
[illegible]
```

```
11    ALPHAL(L)=ATAN2(T2,T1)
      WRITE(6,6002)T1,T2,D(L),ALPHAL(L)
6002  FORMAT(1H ,4F1 .3)
210   CONTINUE

*TEST FOR SITES WITHIN HARDNESS RADIUS
      ISITE=
      DO 23  L=1,NSITE
        IF(FF(L).GT.R)GO TO 23
      K=KK(L)
      IF(Y .GT.( Y(L)+RL(K)))GO TO 23
        ISITE=ISITE+1
        SXX(ISIT )=SX(L)
        SYY(ISIT )=SY(L)
        KKK(ISIT )=KK(L)
      DIST(ISITE)=FN(L)
      ALPH (ISITE)=ALPHAL(L)
23    CONT  U
      WRIT (6,    )ISIT
6003  FORM T(1H  ISITE=,I )
      IF(ISITE.EQ. )GO TO

*AT LEAST ONE R  NOT > R---
      DO     L=1,ISITE
      DISTR= .
      ALPHAR= .
      WRIT (6,3   )
      DO     LL= ,NM
      RN= .
      DO     LLL=1,12
      Y=RANF(-1)
      RN=RN+Y
370    CONTINUE
      RN=RN-6.
      DISTR=DISTR+(1+SIGMAR*RN)*DIST(L)
      RN= .
      DO 3   LLL=1,12
      Y=RANF(-1)
      RN=RN+Y
380   CONTINUE
      RN=RN-6.
      ALPHAR=ALPHAR+ALPHAR(L)+SIGMAF RN
      WRITE(6,3  1)RN,SIGMAR,DIST(L),ALPHA (L),SIGMAF,DISTR,ALPHAR
360    CONTINUE
      AD(L)=DISTR/NM
      AF(L)=ALPH R/NM
      XS(L)=AD(L)*COS(AF(L))+X
      YS(L)=AD(L)*SIN(AF(L))+Y
      WRITE(6,71  )XS(L),YS(L)
350   CONT NU
=SET-UP   OF FO  RKYS
      DO       J=1,N  YS
        RKJ(J)= .
        RK  R= .
        T  P=J-1
        R  J(J)=-PSI+T  P
```

```
*SET-UP LOOP FOR RAY SEGMENTS
        DO 4    I=1,NSEG
     PSITE1= .
     PSITE2= .
          XPR=XH+I*DY
          YPR=YH+I*DY*TAN(PSIJ(J))

*SET-UP LOOP FOR SITES
          DO 3    L=1,ISITE

     IFLAG=1
            T1=SXX(L)-XPR
            T2=SYY(L)-YPR
            R=SQRT(T1*T1+T2*T2)
270  IF(R.GT. . ) GO TO 2
     ALPHA= .
     GO TO  2
240  ALPHA=ATAN2(T2,T1)
250  THETA=ABS(PSIJ(J)-ALPHA)
     IF(THETA.G .P.)THETA=2.  PI-THETA
     KY=KKK(L)
     CALL PKT
     WRITE( ,  11)PK
5011 FORMAT(1H ,3HPK=,F  .3)
     IF(IFLAG.NE.1) GO TO 26
     PSITE1=PSITE1+PK
     IFLAG=2
     T1=XS(L)-YPR
     T2=Y (L)-YPR
     D=SQRT(T1*T1+T2*T2)
     GO TO  2
260  PSITE2=PSITE2+PK
300     CONTINUE

     IF(I.EQ.1)PKTJ(J)=PSITE1
        PKSEG=PKSEG+PSITE2
     WRITE(6,501 )J,PKTJ(J),PKSEG
501  FORMAT(1H ,5HPKTJ(,I2,3H),PKSEG=,2F1 .3)
400    CONTINUE

*SUM PK FOR RAY 'J'
       PKJ(J)=PKJ(J)+PKSEG
     WRITE (6,   1)  J,PKJ(J)
5001 FORMAT(1H ,4HPKJ(,  ,3H)=,F1 .3)

500  CONTINUE

*SORT--PK
     WRITE(6,   )(PKJ(J),PSIJ(J)),PKTJ(J),J=1,NRAYS)
5    FORMAT(1H ,3F .3)
     CALL PKSORT
```

```
*ELIMINAT  RAYS THAT
*FAIL CONSTRAINT TESTS
      JJ=
      XNPW=XN+DX
      DO      J=1,NRAYS
        YNPR=YN+TAN(PSIJ(J))*DX
        T1=XT-XNPR
        T2=YT-YNPR
        GAMPR(J)=ATAN2(  ,T1)
      GAMP (J)=                 )/
      WRITE( ,    )J,PSIJ(J),TAN(PSIJ(J)),YN,YNPR,GAMP (J)
70   FORMAT(1H ,I ,4E   . , E  . )
*******CORRIDOR TEST
        IF(YNPR.LT.   .  .OR. YNPR.GT.    )GO TO
*******WEDGE TEST
        IF(ABS(G  MPR(J)).GT.   )GO TO
        JJ=JJ+1
        PSIJ(JJ)=PSIJ(J)
        GAMPR(JJ)=GAMPR(J)
        PKJ(JJ)=PKJ(J)
      PKTJ(JJ)=PKTJ(J)
60   CONTINUE

      NR=JJ
      WRITE ( ,    )NR
50   FORMAT(1H ,3HNR=,  )

*TEST--MORE THAN ONE MINIMUM
      NMIN=1
      IF(NR.LT.2)GO TO
      DO     J=2,NR
        IF(PKJ(J).NE.PKJ(J-1)) GO TO 7
        NMIN=NMIN+1
700  CONTINUE
 750 WRITE( ,    )NMIN
5006 FORMAT(1H ,5HNMIN=,I )

750  IF(NMIN.GT.1)GO TO 7

*ONE MINIMUM
      INDEX=1
      GO TO
*SELECT RAY ON BASIS OF
*ABSOLUTE VALUE OF TH
77   THETA=   .
      INDEX=1
      DO      J=1,NMIN
        ANG=ABS(   J(J)-      ( ))
        IF(THETA.LT.    )
        THETA=ANG
        INDEX=J
80   CONTINUE
```

```
810   PSIMN=PSIJ(INDEX)
      DY=DX*TAN(PSIMN)
      WRITE(6,5007)INDEX,PSIMN,DY
5007  FORMAT(1H ,17HINDEX,PSIMN,DY=,3(,1F1 .3)
*TOTAL PK,FLIGHT PATH
      PKTOT=PKTOT+PKTJ(INDEX)*CONST
      GO TO 9
*ALL ON X F
850   T1=XT-XN
      WRIT (6,50 8)
5008  FORM T(1H ,5HLOOP -5 )
      T2=YT-YN
      DY=DX*T2/T1
*DISTANC  FLOWN
900   DFLWN=DFLWN+SQRT(DX*DX+DY*DY)
*UPDATE A/C POSITION
      XN=XN+DX
      YN=YN+DY
*PRINT NEW POSITION
      WRITE(6,26  )XN,YN,PSIMN,PKTOT
*AT TARGET?
      T1=XT-XN
      T2=YT-YN
      DT=SQRT(T1*T1+T2*T2)
      IF(DT-DX)910,92 ,9
910   IF(DT.LE.0.3)GO TO 95
 920  IF(YT.NE.YN)GO TO 93
 929  IF(YT.NE.YN)GO TO 93
      DY= ,
      GO TO 94
 930  TEMP=TAN(T2/T1)
      DY=DX*TEMP
940   XN=XN+DX
      YN=YN+DY
      DFLWN=DFLWN+SQRT(DX*DX+DY*DY)
      WRITE(6,26  )XN,YN,PSIMN,PKTOT
 95   WRITE(6,27  )XT,DFLWN
950   CPC=SECOND(CP)
      WRITE(6,27  )XT,DFLWN,CP1,CP2
      IF(T.D.EQ.1)BASEXP=PKTOT
      RATIO=PKTOT/BASEXP
      IND=IND+1
      WRITE(6,32  )RATIO
320   FORMAT(3 H RATIO OF TOTAL EXPOSURE TO BASELINE =,F1 .3)
      GO TO 1
```

```
*END OF INPUT
999  WRITE (6,200)

9999 STOP
100  FORMAT(6I5,2F1 .1)
110  FORMAT(6F1 .1)
120  FORMAT(2F1 .1,I )

200  FORMAT(1H1///  X,  H [illegible] FLIGHT PATH INPUT SUMMARY---// X,  HCH
    1ECKER 1--,F .3,1H,,F .3, X,1 H /( VELOCITY--MIN=,F .1, X,  H [illegible]
    20F WIDTH=,F8. /1 X,3H --,F .3,1H,,F8.3,1 X,4HMAX=,F .1, X,1 H [illegible]
    3 [illegible] US=,F .1// X,  H [illegible]=,I2, X,  H [illegible] STEPS=,I2, X,3HNO SITES=,I ,
    4 X,1 HNO SITE TYPES=, //  X,  HNO. OF MEASUREMENTS=,I , X,  H [illegible]
    5(-ANGLE)=,F .2, X,  H [illegible](ANGLE)=,F .3,5H DEG.///  X,23H [illegible] DATA--
    6EACH SITE TYPE /)
210  FORMAT(/1 X,1 HSITE TYPE=,I , X,1 HSITE TYPE NO=,I2//13X,2 H [illegible]
    1S=[illegible]GS,  [illegible]EN  [illegible]S)
220  FORMAT( ( X,F .3))
230  FORMAT(// X,  HSITE [illegible]---/ 1X,  HX- [illegible]OTATED Y-ROTATED/)
240  FORMAT(1 X,F .3, X,F .3, X,I , X,I )
250  FORMAT(1H1/// X,1 H PROGRAM OUTPUT---//12X,
    19HX- [illegible]OTATED,1X,  HY-ROTATED,2X, [illegible] ( [illegible] D),2X,8HEXPOSURE/)
260  FORMAT(1 X,I( X,F .3), X,F .  , X,F . )
270  FORMAT(//1 X,  H [illegible] LINE DISTANCE=,F8.3,1 X,1 HDISTANCE F [illegible]
    1=,F  .3/ X,  F1 . )
280  FORMAT(1H1/// X,  HS [illegible] ,I ,2 H DOES NOT MATCH LIST,( I ))
290  FORMAT(1H1//1 X,  H [illegible] NAL COMPLETION**)
300  FORMAT(1H , X, [illegible] DIST ALPHA  SIGMAF DISTP  ALPHAP)
3001 FORMAT(1H ,F .3,  F .3)
310  FORMAT(9H (XS,YS)=,2F  . )

     END
```

```
      SUBROUTINE PKTABL
*TO OBTAIN PK VALUE AS FUNCTION OF
*DISTANCE TO SITE(D) AND AZIMUTH
*ANGLE(THETA)
      COMMON/DATA/D,INTV(20),NRNGS(20),NSEC2(20),PK,PKTAB(10,8,20),
     1             FL(20),THETA,PI,KX
      TEMP=INTV(KX)
      TEMP1=NSEC2(KX)
      PK=0.
*DISTANCE TO SITE VS LETHAL RADIUS
      IF(D-FL(KX))10,20,100
*D<FL,COMPUTE RING
10    M=(D/TEMP)+1.
      GO TO 30
*D=FL,OUTER RING
20    M=NRNGS(KX)
*TEST ANGLE,OBTAIN SECTOR
30    IF(THETA-PI)40,50,80
*THETA<PI
40    N=(THETA*TEMP1/PI)+1.0
      GO TO 60
*THETA=PI
50    N=NSEC2(KX)
*
60    PK=PKTAB(M,N,KX)
      GO TO 100
*ERROR
80    WRITE(6,90)THETA
90    FORMAT(//5X,13HERROR--PKTABL,2X,6HTHETA=,E14.7)
      STOP
100   RETURN
      END
```

```
      SUBROUTINE PKSORT

*USES "BUBBLE" SORT TECHNIQUE
*TO ARRANGE TOTAL PK FOR EACH
*RAY IN ASCENDING ORDER

      COMMON/CNCT/NRAYS,PKJ(11),PSIJ(11),PKTJ(11)

      NRM1=NRAYS-1
      DO 100 I=1,NRM1
      IFLAG=0
      NRMI=NRAYS-I
      DO 50 J=1,NRMI
      IF(PKJ(J+1).GE.PKJ(J))GO TO 50
      T1=PKJ(J)
      T2=PSIJ(J)
      T3=PKTJ(J)
      PKJ(J)=PKJ(J+1)
      PSIJ(J)=PSIJ(J+1)
      PKTJ(J)=PKTJ(J+1)
      PKJ(J+1)=T1
      PSIJ(J+1)=T2
      PKTJ(J+1)=T3
      IFLAG=1
50    CONTINUE
      IF(IFLAG.EQ.0)GO TO 200
100   CONTINUE

200   RETURN
      END
```

Appendix B

FORTRAN Code Listing of the Revised

TMPSA Program

```
      PROGRAM [illegible] THZ(INPUT,OUTPUT,TA[illegible]=INPUT,[illegible]=OUTPUT)
****************[illegible]
*PROGRAM TO COMPUTE [illegible]
*PATH BETWEEN 2 CHECKPOINTS
***[illegible]
*MULTIPLE TYPE [illegible]
*
*MAX LIMIT [illegible] RAYS--
*     RAYS=1[illegible]
*     STEPS=[illegible]
*     SITES=1
*     SITE TYPES=[illegible]
*     RING /SITE TYPE=[illegible]
*     SECTORS/SITE TYPE=[illegible]
*
*SUBSCRIPTS--
*     I=STEPS
*     J=RAYS
*     K=SITE TYPES
*     L=STEPS
***[illegible]
*
      COMMON/[illegible]/RAY[illegible],PK[illegible](1[illegible]),P[illegible](1[illegible]),PK[illegible](1[illegible])
      COMMON/[illegible],[illegible],[illegible](1 ),[illegible](2 ),PK,P[illegible](1 ,[illegible],2 ),
     1          [illegible]L(2 ),[illegible],[illegible],KY
      DIMENSION X[illegible](1  ),YS(1 [illegible]),TX(1  ),TY(1  ),ITYP(1  ),S[illegible](1[illegible]),
     1          [illegible](1  ),SXY(1  ),SYY(1  )
      DIMENSION [illegible](2 ),[illegible](1  ),[illegible](2 ),KKK(1  )
      DIMENSION [illegible](1  ),[illegible](1  ),[illegible](1  ),A[illegible](1  ),[illegible](1  )

      PI=3.1[illegible]

*CARD INPUT*******[illegible]

*NO. ANGLES,STEPS,SITES,SITE TYPES,NO. OF MEASUREMENTS
      PER SITE, STANDARD DEVIATION OF RANGE & AZIMUTH
      IND=1
      RATIO= .
10    READ(5,1  )[illegible],NSTEP,NSITE,[illegible]TYPS,[illegible],SIGMA[illegible],SIGMAD
      WRITE(6, 1  )[illegible],NSTEP,NSITE,NTYPS,[illegible],SIGMA[illegible],SIGMAD
41[illegible] FORMAT(1H ,5I[illegible] ,2F[illegible].[illegible])

*TEST END OF FILE
      IF(EOF([illegible]).[illegible])GO TO [illegible]

*CHECKPOINTS
      READ([illegible],1[illegible]  )XI,YI,XF,YF
      WRITE([illegible], [illegible]  )XI,YI,XF,YF
42[illegible] FORMAT(1H ,4F[illegible].[illegible])
```

```
*AWARENESS RADIUS,MIN&MAX A/C VELOCITY,CORRIDOR WIDTH
      READ(5,11  )R,VMN,VMX,WD
      WRIT (6,.2  )R,V  ,V  X,WD

*SITE DAT  ---
*NO. RINGS,SPOT  ES,INTERVAL,TYPE
      DO 2   K=1, TYPE
        READ( ,1   )NRNGS(K),NSPOT(K),I  V(K),ITP(K)
        NS OT2(K)=NSPOT(K)/2
      WRITE(6, 1   )NRNGS(K),NSPOT(K),INTV(K),ITP(K),NS OT2(K)
20    CONTINUE

*SITE PK DATA
      DO 3   K=1, TYPE
        MT=NR GS(K)
        NT=NSPOT2(K)
        READ( ,1    )((PKTAB(M,N,K),M=1,MT),N=1,NT)
      WRITE(6, 2   )((PKTAB(M,N,K),M=1,MT),N=1,NT)
30    CONTINUE

*SITE  OC  DINATES,TYPE
50    DO     L=1, SITE
        READ( ,1   )SX(L),SY(L),STYP(L)
      WRITE( ,    )SX(L),SY(L),STYP(L)
40    FORMAT(1H ,2F  .2,I )
60    CONTINUE

*END CARD INPUT

*INITIALIZATION
65    NRAYS=JSLICE+1
      CP1=SECOND(CP)
      PSI= .
      DPSI= .
      PSIMN= .
      PKTOT= .
      DELWN= .
      TEMP=NSEG
      DX=R/TEMP
      TEMP=VMN/VMX
      IF(TEMP.GT.1. )TEMP=1.
      PSI=ACOS(TEMP)
      PSI=INT(PS  1    .+.    )    .
      WRIT (6,  )PSI
701   FORMAT( H PSI=,F  . )
      TEMP=JSLIC
      DPSI=(2.   PSI)/TEMP
      TEMP=NSEG
      CONST=3    .   /(1.  P  /M )
      SIGN F=SIG  AD PI/    .
```

```
*SET-UP ARRAY R LATING
*SITE NO. TO SITE TYPE
      DO 6  L=1, SITE
        KK(L)=
        DO 7   K=1,NTYPS
          KK(L)=KK(L)+1
          IF(STYP(L).EQ.ITP(K))GO TO 6
7       CONTINUE
****** ERROR-NO MATCH
        LL=L
      STOP
6     CONTINUE

*LETHAL RADIUS
      DO    K=1,NTYPS
        RL(K)=   GS(K)
9     CONTINUE


*INITIAL A/C POSITION
11    XN=YO
      YN=YO
      XT=YF
      YT=YF

*END INITIALIZATION

*PRINT INPUT SUMMARY

      DO 12  K=1,NTYPS
        NT=NUMGS(K)
        NT=NSIC2(K)
120   CONTINUE


*DISTANCE--SITE TO A/C
      WRITE(6,6  5)
6005  FORMAT(  1H     T1          T2         DN(L)      ALPHAL(L))
200   DO 21  L=1,NSITE
        T1=SY(L)-XN
        T2=SY(L)-YN
        DN(L)=SQ T(T1
600   FORMAT(  H  1=,F1  .  ,  T2=,F1  .1)
     . IF(T . E . ) GO TO
      ALPHAL(L)=
      GO TO 21
 211  ALPHAL(L)=
      W IT  ( ,    2)T1,T ,D (L),ALPHAL(L)
6  2  FORMAT(1H  ,  F1  .3)
21    CONTINUE
```

```
*TEST FOR SITES WITHIN AWARENESS RADIUS
      ISIT =
      DO 23  L=1,NSITE
        IF(DN(L).GT.R)GO TO 23
      K=KK(L)
      IF(YM.GT.(YK(L)+FL(K)))GO TO 23
        ISITE=ISITE+1
        SXY(ISIT )=SY(L)
        SYY(ISIT )=YY(L)
        KKK(ISIT )=KK(L)
      DIST(ISITE)=DN(L)
      ALPHAE(ISITE)=ALPHA (L)
23    CONTINUE
      WRITE(6,  3)ISITE
6  3 FORMAT( H  SITE=, )
      IF(ISITE.EQ. )GO TO

*AT LEAST ONE P   NIT > R---
      RND=    TIM+1 1
      CALL RANSET(RND)
      DO 3    L=1,ISITE
      DISTP= .
      ALPHAP= .
      WRITE(6,3    )
      DO 3    LL=1,NM
      RN= .
      DO 3    LLL=1,12
      Y=RANF(-1)
      RN=RN+Y
370    CONTINUE
      RN=RN-6.
      DISTP=DISTP+(1+SIGMAR*RN)*DIST(L)
      RN= .
      DO 38  LLL=1,12
      Y=RANF(-1)
      RN=RN+Y
380   CONTINUE
      RN=RN-6.
      ALPHAP=ALPHAP+ALPHAR(L)+SIGMAF*RN
      WRITE(6,3  1)RN,SIGMAR,DIST(L),ALPHA (L),SIGMAF,DISTP,ALPHAP
36     CONTINUE
      AD(L)=DISTP/NM
      AF(L)=ALPH P/NM
      XS(L)=AD(L)*COS(AF(L))+XM
      YS(L)=AD(L)*SIN( F(L))+YM
      WRITE(6,31  )XS(L),Y (L)
35    CONTINUE
=SET-UP LOOP FO  RAYS
      DO       J=1,NRAYS
       PKJ(J)= .
       PKJIC= .
       TEMP= J-1
       P   J(J)=-PS.+
```

```
*SET-UP LOOP FO[illegible] RAY SEGMENTS
          DO 4[illegible]  I=1,NSEG
        PSITE1= .
        PSITE2= .
            XP[illegible]=YN+I[illegible]DX
            YP[illegible]=Y[illegible]+I[illegible]DX[illegible]TAN(PSI[illegible]J(J))

*SET-UP LOOP FO[illegible] SITES
            DO 3[illegible]  L=1,ISITE

        IFLAG=1
              T1=SYX(L)-XP[illegible]
              T2=SYY(L)-YP[illegible]
              D=SQ[illegible]T(T1[illegible]T1+T2[illegible]T2)
270     IF(D.GT. . ) GO TO 2[illegible]
        ALPHA= .
        GO TO 2[illegible]
24[illegible]     ALPHA=ATAN2(T2,T1)
25[illegible]     THETA=ABS(PSIJ(J)-ALPHA)
        IF(TH[illegible].G[illegible].PI)THETA=2.[illegible]PI-THETA
        KX=KKK(L)
        CALL PK[illegible]
        WRITE(6,5[illegible]11)PK
5011    FORMAT(1H ,3HPK=,F1[illegible].3)
        IF(IFLAG.[illegible].1) GO TO 26[illegible]
        PSITE1=PSITE1+PK
        IFLAG=2
        T1=X[illegible](L)-XPP
        T2=YS(L)-YPP
        D=SQRT(T1*T1+T2[illegible]T2)
        GO TO 2[illegible]
26[illegible]     PSITE2=PSITE2+PK
300         CONTINUE

        IF(I.EQ.1)PKTJ(J)=PSITE1
            PKSEG=PKSEG+PSITE2
        WRITE(6,5[illegible])J,PKTJ(J),PKSEG
501[illegible]    FORMAT(1H ,5HPKTJ(,I[illegible],3H),PKSEG=,2F1[illegible].3)
4[illegible]0        CONTINUE

*SUM PK FOR RAY 'J'
          PKJ(J)=PKJ(J)+PKSEG
        WRITE(6,[illegible])J,PKJ(J)
50[illegible]1    FORMAT(1H ,[illegible]HPKJ(,I2,[illegible]H=,F1[illegible].[illegible])

50[illegible]     CONTINUE

*SORT--PK
        WRITE(6,[illegible])(P[illegible]J(J),PSIJ(J),PK[illegible]J(J)),J=1,N[illegible]RAYS)
5[illegible]04    FORMAT(1[illegible],3F[illegible].[illegible])
        CALL PK[illegible]
```

AD-A101 136 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOO--ETC F/G 1/3
QUANTIFYING REACTIVE MANEUVERS.(U)
MAR 81 J J ALT
UNCLASSIFIED AFIT/GST/OS/81M-1 NL

2 OF 4
AD A
101136

```
*ELIMINAT  RAYS THAT
*FAIL CONSTRAINT TESTS
      JJ=
      XNPP=XN+DX
      DO    J=1,NRAYS
        YNPP=YN+TAN(PSIJ(J)) DX
        T1=YI-YN-R
        T2=YI-YNPP
        GAMPE(J)=ATAN2(T2,T1)
      GAMPE(J)=T T(GAMPE(J) 1    .+. )/1    .
      WRIT (6,7    )J,PSIJ(J),TAN(PSIJ(J)),YI,YNPP,GAMPE(J)
7   FORMAT(1H ,I  ,F   .7,F  . )
****  CONFIDENCE TEST
        IF(YNPP. T.2. .  . YNPP.GT.  .)GO TO
****** WIDGE TEST
        IF(ABS(GAMPE(J)).GT.PSI)GO TO
        JJ=JJ+1
        PSIJ(JJ)=PSIJ(J)
        GAMPE(JJ)=GAMPE(J)
        PKJ(JJ)=PKJ(J)
      PKTJ(JJ)=PKTJ(J)
6     CONTINUE

      NR=JJ
      WRIT (6,    )NR
5     FORMAT(1H ,3HNR=,I )

*TEST--MORE THAN ONE PKMIN?
      NMIN=1
      IF(N .LT.2)GO TO
      DO     J=2,NR
        IF(PKJ(J).NE.PKJ(J-1)) GO TO 7
        NMIN=NMIN+1
700   CONTINUE
 75   WRITE(6,5  )NMIN
5006 FORMAT(1H ,5HNMIN=,I )

750  IF(NMIN.GT.1)GO TO 7

*ONE MINIMUM
      INDEY=1
      GO TO 81
*SELECT RAY ON BASIS OF
*ABSOLUTE VALUE OF THETA
77   THETA=   .
      INDEY=1
      DO     J=1,NMIN
        ANG=ABS(PSIJ(J)-      (J))
        IF(THETA.LT.   )GO TO
        THETA=AN
        INDEY=J
800   CONTINUE
```

```
810   PSIMM=PSIJ(INDEX)
      DY=DX*TAN(PSIMM)
5007  FORMAT(1H ,17HIN ETY,PSIAN,DY=,I ,3F1 .3)
*TOTAL PK,FLIGHT PATH
      PKTOT=PKTOT+PKTJ(IND Y)*CONST
      GO TO 9
*ALL DN > F
850   T1=XT-XN
      WRITE (6,   8)
5008  FORMAT(1H ,  HLOOP   )
      T2=YT-YN
      DY=DX*T2/T1
*DISTANCE FLOWN
900   DFLWN=DFLWN+SQRT(DX*DX+DY*DY)
*UPDATE A/C POSITION
      XN=XN+DX
      YN=YN+DY
*PRINT NEW POSITION
*AT TARGET?
      T1=XT-YN
      T2=YT-YN
      DT=SQRT(T1*T1+T2*T2)
      IF(DT-DX)9  ,92  ,2
910   IF(DT.LE.  .5)GO TO 9
 92   IF(YT.NE.Y )GO TO 93
920   IF(YT.NE.Y )GO TO 95
      DY= .
      GO TO 9
 930  TEMP=TAN(T2/T1)
      DY=DX*TEMP
940   XN=XN+DX
      YN=YN+DY
      DFLWN=DFLWN+SQRT(DX*DX+DY*DY)
 95   WRITE(6,32  )XT,DFLWN
950   DP2=DECODE(DP)
      IF(IND.EQ.1)PKCU X =PKTOT
      RATIO=PKTOT/P   X
      WRITE(6,2   )XN,Y ,P    N,PKTOT
      IND=IND+1
 32   FORMAT(70H RATIO OF TOTAL EXPOSURE TO BASELINE =,F1 .3)
      GO TO 2
```

```
*END OF INPUT
99   WRITE(6,2[illegible] )

9999 STOP
100  FORMAT( I[illegible],2F1 .1)
110  FORMAT(2F1 .1)
120  FORMAT(2F1 .1,I[illegible])

200  FORMAT(1H1///[illegible] X,[illegible] FLIGHT PATH INPUT SUMMARY---// X,[illegible]
    1ECKER 1--,[illegible],3,1H,,F[illegible] X,1 HA/C VELOCITY--MIN=,F .1, X,[illegible]
    20  WIDTH=,F[illegible] --,[illegible],F8.3,18X,6HMAX=,F .1, X,[illegible]
    3 RADIUS=,F .1/// X,[illegible]=,I2, X,[illegible] STEPS=,I2, X,[illegible]
    [illegible] X,[illegible] SITE TYPES=,I2//[illegible],2 HNO. OF MEASUREMENTS=,I[illegible], X,[illegible]
    5(RANGE)=,F .2, X,[illegible](ANGLE)=,F1 .2,5H DEG.///[illegible]X,23H[illegible] DATA--
    [illegible]EACH SITE TYPE/)
21   FORMAT(/3 X,[illegible] TYPE=,I[illegible], X,1[illegible]SITE TYPE NO=,I2//13X,2[illegible]
    1S=[illegible]
220  FORMAT( ([illegible] X,F[illegible] .7))
230  FORMAT(//[illegible] X,[illegible] DATA---/11X,1[illegible]HX-ROTATED Y-ROTATED/)
240  FORMAT(1[illegible]X,F[illegible].2,[illegible]X,F .2, X,I[illegible], X,I[illegible])
250  FORMAT(1H1///[illegible] OUTPUT---//1[illegible]X,
    19HY-[illegible],1X,[illegible],2X,[illegible],2X,8HEXPOSURE/)
260  FORMAT(1 X,2([illegible]X,F[illegible].2), X,F[illegible], 7X,F[illegible].2)
270  FORMAT(//1 X,[illegible] DISTANCE=,F5.3,1 X,1[illegible]HDISTANCE[illegible]
    1=,F .3/ X,[illegible])
280  FORMAT(1H1///[illegible] X,[illegible] NUMBER ,I[illegible],2 H DOES NOT MATCH LIST,(3I ))
290  FORMAT(1H1//1 X,[illegible] NORMAL COMPLETION***)
300  FORMAT(1H ,[illegible]X, [illegible] DIST  ALPHAR SIGMAF DISTP  ALPHAP)
3001 FORMAT(1H ,F[illegible],[illegible]F .3)
310  FORMAT(9H (XS,YS)=,2F[illegible] .2)

     END
```

```
      SUBROUTINE PKTABL

*TO OBTAIN PK VALUE AS FUNCTION OF
*DISTANCE TO SITE(D) AND AZIMUTH
*ANGLE(THETA)

      COMMON/CTABL/D,INTV([illegible]),NRNGS([illegible]),NSEC2([illegible]),PK,PKTAB([illegible],[illegible],[illegible]),
     1             RL([illegible]),THETA,PI,KX

      TEMP=INTV(KX)
      TEMP1=NSEC2(KX)
      PK=[illegible].

*DISTANCE TO SITE VS LETHAL RADIUS
      IF(D-RL(KX))1[illegible],2[illegible],3[illegible]

*D<RL,COMPUTE RING
10    M=(D/TEMP)+1.
      GO TO 3[illegible]

*D=RL,OUTER RING
20    M=NRNGS(KX)

*TEST ANGLE,OBTAIN SECTOR
30    IF(THETA-PI)4[illegible],5[illegible],8[illegible]

*THETA<PI
40    N=(THETA*TEMP1/PI)+1.
      GO TO 6[illegible]

*THETA=PI
50    N=NSEC2(KX)

*
60    PK=PKTAB(M,N,KX)
      GO TO 1[illegible]

*ERROR
80    WRITE(6,[illegible])THETA
90    FORMAT(//[illegible]X,13HE[illegible]--PKTABL,2X,[illegible]H[illegible]=,E[illegible].[illegible])
      STOP

100   RETURN
      END
```

```
      SUBROUTINE PKSORT

*USES "BUBBLE" SORT TECHNIQUE
*TO ARRANGE THE PK FOR EACH
*RAY IN ASCENDING ORDER

      COMMON/OF[illegible]T/NRAYS,PKJ(11),PSIJ(11),PKTJ(11)

      NRM1=NRAYS-1
      DO 100 I=1,NRM1
      IFLAG=0
      NRMI=NRAYS-I
      DO 50 J=1,NRMI
      IF(PKJ(J+1).GE.PKJ(J))GO TO 50
      T1=PKJ(J)
      T2=PSIJ(J)
      T3=PKTJ(J)
      PKJ(J)=PKJ(J+1)
      PSIJ(J)=PSIJ(J+1)
      PKTJ(J)=PKTJ(J+1)
      PKJ(J+1)=T1
      PSIJ(J+1)=T2
      PKTJ(J+1)=T3
      IFLAG=1
50    CONTINUE
      IF(IFLAG.EQ.0)GO TO 200
100   CONTINUE

200   RETURN
      END
```

Appendix C

Raw Output Data

Appendix C1

Basic Model Output

OPTIMUM FLIGHT PATH INPUT SUMMARY---

```
CHECKPT 1--   [illegible],  35.[illegible]     A/C VELOCITY--MIN=648.[illegible]     CORRIDOR WIDTH= 2[illegible].
        2-- 1[illegible],  35.[illegible]                   MAX=64[illegible].[illegible]      AWARE RADIUS= 2[illegible].

NRAYS=11     NO STEPS=25     NO SITES= 37     NO SITE TYPES=    1

NO. OF MEASUREMENTS=    1     SIGMA(RANGE)=      [illegible].[illegible]     SIGMA(ANGLE)=       .[illegible] DEG.


PK DATA--EACH SITE TYPE


    SITE TYPE=  1[illegible]     SITE TYPE NO= 1

       COLUMNS=RINGS,ROWS=SECTORS
 .133      .12[illegible]      .117      .[illegible]79
 .272      .217      .1[illegible]2      .1[illegible]7
 .281      .29[illegible]      .25[illegible]      .13[illegible]
 .231      .137      .[illegible]33      .[illegible]
 .[illegible]75      .[illegible]      .[illegible]12      .[illegible]25
```

SITE DATA---

	X-ROTATED	Y-ROTATED		
	14.00	39.00	100	1
	53.00	27.00	100	1
	24.00	35.00	100	1
	53.00	42.00	100	1
	81.00	3[illegible].00	100	1
	7[illegible].00	4[illegible].00	100	1
	18.00	43.00	100	1
	56.00	64.00	100	1
	84.00	43.00	100	1
	62.00	25.00	100	1
	69.00	49.00	100	1
	27.00	52.00	100	1
	15.00	49.00	100	1
	39.00	54.00	100	1
	6[illegible].00	16.00	100	1
	18.00	2.00	100	1
	71.00	54.00	100	1
	94.00	55.00	100	1
	57.00	5[illegible].00	100	1
	38.00	17.00	100	1
	56.00	15.00	100	1
	18.00	13.00	100	1
	35.00	2[illegible].00	100	1
	67.00	59.00	100	1
	47.00	14.00	100	1
	8[illegible].00	6.00	100	1
	55.00	22.00	100	1
	18.00	54.00	100	1
	83.00	59.00	100	1
	76.00	58.00	100	1
	9[illegible].00	49.00	100	1
	76.00	16.00	100	1
	94.00	62.00	100	1
	45.00	54.00	100	1
	6[illegible].00	2.00	100	1
	65.00	16.00	100	1
	89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	35.00	[illegible]	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	[illegible]	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.82
10.00	35.00	[illegible]	5.39
11.00	35.00	[illegible]	7.02
12.00	35.00	[illegible]	8.86
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.1[illegible]
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	20.13
18.00	35.00	[illegible]	23.08
19.00	35.00	[illegible]	24.96
20.00	35.00	[illegible]	26.63
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.01

T1= [illegible] T2= [illegible]

25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.15
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.06
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.05
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.06
[illegible]	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06
[illegible]	35.00	[illegible]	36.47
[illegible]	35.00	[illegible]	36.92
48.00	35.00	[illegible]	37.36
[illegible]	35.00	[illegible]	37.61
[illegible]	35.00	[illegible]	38.79
51.00	35.00	[illegible]	39.77
52.00	35.00	[illegible]	40.98

53.00	35.00	[illegible]	42.18
54.00	35.00	[illegible]	42.69
55.00	35.00	[illegible]	43.19
56.00	35.00	[illegible]	43.70
57.00	35.00	[illegible]	43.90
58.00	35.00	[illegible]	44.10
59.00	35.00	[illegible]	44.30
60.00	35.00	[illegible]	44.43
61.00	35.00	[illegible]	44.43
62.00	35.00	[illegible]	44.66
63.00	35.00	[illegible]	44.66
64.00	35.00	[illegible]	44.66
65.00	35.00	[illegible]	44.66
66.00	35.00	[illegible]	44.88
67.00	35.00	[illegible]	45.11
68.00	35.00	[illegible]	45.32
69.00	35.00	[illegible]	45.54
70.00	35.00	[illegible]	45.77
71.00	35.00	[illegible]	45.83
72.00	35.00	[illegible]	45.99
73.00	35.00	[illegible]	46.33
74.00	35.00	[illegible]	46.87
75.00	35.00	[illegible]	48.15
76.00	35.00	[illegible]	49.43
77.00	35.00	[illegible]	50.19
78.00	35.00	[illegible]	52.06
79.00	35.00	[illegible]	53.92
80.00	35.00	[illegible]	55.78
81.00	35.00	[illegible]	57.64
82.00	35.00	[illegible]	59.31
83.00	35.00	[illegible]	60.97
84.00	35.00	[illegible]	62.64
85.00	35.00	[illegible]	62.92
86.00	35.00	[illegible]	63.21
87.00	35.00	[illegible]	63.52
88.00	35.00	[illegible]	63.72
89.00	35.00	[illegible]	63.93
90.00	35.00	[illegible]	63.99
91.00	35.00	[illegible]	63.99
92.00	35.00	[illegible]	63.99
93.00	35.00	[illegible]	63.99
94.00	35.00	[illegible]	63.99
95.00	35.00	[illegible]	63.99
96.00	35.00	[illegible]	63.99
97.00	35.00	[illegible]	63.99
98.00	35.00	[illegible]	63.99
99.00	35.00	[illegible]	63.99
100.00	35.00	[illegible]	63.99

Appendix C2

Control Model Output

(see Table 2)

```
                OPTIMUM FLIGHT PATH INPUT SUMMARY---

CHECKPT 1--   [illegible],  35.[illegible]    A/C VELOCITY--MIN=648.[illegible]    CORRIDOR WIDTH= [illegible].
        2--   133.[illegible],  35.[illegible]                  MAX=648.[illegible]      AWARE RADIUS= [illegible].

NRAYS=11     NO STEPS=25     NO SITES= 38     NO SITE TYPES=    1

NO. OF MEASUREMENTS=    1     SIGMA(RANGE)=      [illegible]     SIGMA(ANGLE)=       [illegible] DEG.


PK DATA--EACH SITE TYPE


    SITE TYPE=  1[illegible]     SITE TYPE NO= 1

        COLUMNS=RINGS,ROWS=SECTORS
 .133       .125       .117       .079
 .272       .217       .172       .107
 .281       .293       .251       .136
 .231       .137       .239       .144
 .075       .046       .312       .125
```

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	1.00	1
53.00	27.00	1.00	1
26.00	35.00	1.00	1
53.00	42.00	1.00	1
81.00	30.00	1.00	1
77.00	44.00	1.00	1
18.00	53.00	1.00	1
56.00	44.00	1.00	1
34.00	43.00	1.00	1
52.00	25.00	1.00	1
56.00	27.00	1.00	1
59.00	49.00	1.00	1
27.00	52.00	1.00	1
15.00	49.00	1.00	1
39.00	54.00	1.00	1
55.00	18.00	1.00	1
12.00	2.00	1.00	1
71.00	54.00	1.00	1
94.00	65.00	1.00	1
57.00	51.00	1.00	1
38.00	17.00	1.00	1
56.00	15.00	1.00	1
18.00	13.00	1.00	1
35.00	20.00	1.00	1
57.00	59.00	1.00	1
47.00	14.00	1.00	1
68.00	6.00	1.00	1
55.00	22.00	1.00	1
18.00	54.00	1.00	1
83.00	59.00	1.00	1
75.00	58.00	1.00	1
90.00	49.00	1.00	1
76.00	18.00	1.00	1
94.00	82.00	1.00	1
45.00	30.00	1.00	1
6.00	2.00	1.00	1
65.00	16.00	1.00	1
59.00	15.00	1.00	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	35.00	[illegible]	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	[illegible]	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.82
10.00	35.00	[illegible]	5.38
11.00	35.00	[illegible]	7.02
12.00	35.00	[illegible]	8.88
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.1[illegible]
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	20.13
18.00	35.00	[illegible]	23.08
19.00	35.00	[illegible]	24.96
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.01

T1= 0. T2= 1.

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.15
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.06
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.06
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.06
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06
46.00	35.00	[illegible]	36.47
47.00	35.00	[illegible]	36.92
48.00	35.00	[illegible]	37.36
49.00	35.00	[illegible]	37.81
50.00	35.00	[illegible]	39.01
51.00	35.00	[illegible]	40.22
52.00	35.00	[illegible]	41.64

53.00	35.00	[illegible]	43.07
54.00	35.00	[illegible]	44.34
55.00	35.00	[illegible]	45.61
56.00	35.00	[illegible]	46.87
57.00	35.00	[illegible]	47.29
58.00	35.00	[illegible]	47.71
59.00	35.00	[illegible]	47.97
60.00	35.00	[illegible]	48.17
61.00	35.00	[illegible]	48.24
62.00	35.00	[illegible]	48.53
63.00	35.00	[illegible]	48.53
64.00	35.00	[illegible]	48.53
65.00	35.00	[illegible]	48.53
66.00	35.00	[illegible]	48.75
67.00	35.00	[illegible]	48.97
68.00	35.00	[illegible]	49.19
69.00	35.00	[illegible]	49.42
70.00	35.00	[illegible]	49.64
71.00	35.00	[illegible]	49.71
72.00	35.00	[illegible]	49.77
73.00	35.00	[illegible]	50.26
74.00	35.00	[illegible]	51.74
75.00	35.00	[illegible]	52.02
76.00	35.00	[illegible]	53.31
77.00	35.00	[illegible]	54.67
78.00	35.00	[illegible]	55.93
79.00	35.00	[illegible]	57.79
80.00	35.00	[illegible]	59.65
81.00	35.00	[illegible]	61.51
82.00	35.00	[illegible]	63.18
83.00	35.00	[illegible]	64.84
84.00	35.00	[illegible]	66.51
85.00	35.00	[illegible]	66.79
86.00	35.00	[illegible]	67.08
87.00	35.00	[illegible]	67.39
88.00	35.00	[illegible]	67.59
89.00	35.00	[illegible]	67.80
90.00	35.00	[illegible]	67.87
91.00	35.00	[illegible]	67.87
92.00	35.00	[illegible]	67.87
93.00	35.00	[illegible]	67.87
94.00	35.00	[illegible]	67.87
95.00	35.00	[illegible]	67.87
96.00	35.00	[illegible]	67.87
97.00	35.00	[illegible]	67.87
98.00	35.00	[illegible]	67.87
99.00	35.00	[illegible]	67.87
100.00	35.00	[illegible]	67.87

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	3[illegible].00	100	1
7[illegible].00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
55.00	3[illegible].00	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	54.00	100	1
5[illegible].00	18.00	100	1
18.00	2.00	1	1
71.00	54.00	100	1
94.00	65.00	100	1
57.00	5[illegible].00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
35.00	2[illegible].00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
6[illegible].00	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1

9[illegible].00	49.00	100	1
76.00	16.00	100	1
94.00	52.00	100	1
45.00	54.00	100	1
6[illegible].00	2.00	100	1
66.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	35.00	[illegible]	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	[illegible]	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.82
10.00	35.00	[illegible]	5.38
11.00	35.00	[illegible]	7.02
12.00	35.00	[illegible]	8.88
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.10
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	20.13
18.00	35.00	[illegible]	23.08
19.00	35.00	[illegible]	24.96
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.01

T1= 0.0T2= [illegible]

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.15
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.06
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.06
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.06
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06
46.00	35.00	[illegible]	36.47
47.00	35.00	[illegible]	36.92
48.00	35.00	[illegible]	37.78
49.00	35.00	[illegible]	38.64
50.00	35.00	[illegible]	41.91
51.00	35.00	[illegible]	43.17
52.00	35.00	[illegible]	45.14

53.00	35.00	0.0000	47.98
54.00	35.00	0.0000	50.13
55.00	35.00	0.0000	52.27
56.00	35.00	0.0000	54.42
57.00	35.00	0.0000	56.06
58.00	35.00	0.0000	57.71
59.00	35.00	0.0000	59.35
60.00	35.00	0.0000	59.79
61.00	35.00	0.0000	59.92
62.00	35.00	0.0000	60.38
63.00	35.00	0.0000	60.52
64.00	35.00	0.0000	60.66
65.00	35.00	0.0000	60.65
66.00	35.00	0.0000	60.88
67.00	35.00	0.0000	61.11
68.00	35.00	0.0000	61.33
69.00	35.00	0.0000	61.56
70.00	35.00	0.0000	61.77
71.00	35.00	0.0000	61.64
72.00	35.00	0.0000	61.91
73.00	35.00	0.0000	62.39
74.00	35.00	0.0000	62.87
75.00	35.00	0.0000	64.16
76.00	35.00	0.0000	65.44
77.00	35.00	0.0000	66.20
78.00	35.00	0.0000	68.06
79.00	35.00	0.0000	69.92
80.00	35.00	0.0000	71.78
81.00	35.00	0.0000	73.64
82.00	35.00	0.0000	75.31
83.00	35.00	0.0000	76.98
84.00	35.00	0.0000	78.64
85.00	35.00	0.0000	78.93
86.00	35.00	0.0000	79.21
87.00	35.00	0.0000	79.52
88.00	35.00	0.0000	79.73
89.00	35.00	0.0000	79.93
90.00	35.00	0.0000	80.00
91.00	35.00	0.0000	80.00
92.00	35.00	0.0000	80.00
93.00	35.00	0.0000	80.00
94.00	35.00	0.0000	80.00
95.00	35.00	0.0000	80.00
96.00	35.00	0.0000	80.00
97.00	35.00	0.0000	80.00
98.00	35.00	0.0000	80.00
99.00	35.00	0.0000	80.00
100.00	35.00	0.0000	80.00

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	[illegible]	100	1
[illegible]	44.00	100	1
18.00	43.00	100	1
56.00	[illegible]	100	1
84.00	43.00	100	1
62.00	25.00	100	1
55.00	32.50	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	54.00	100	1
[illegible]	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	65.00	100	1
57.00	[illegible]	100	1
36.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
35.00	[illegible]	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	69.00	100	1
75.00	58.00	100	1

[illegible]	49.00	100	1
78.00	18.00	100	1
94.00	52.00	100	1
45.00	34.00	100	1
[illegible]	2.00	100	1
56.00	16.00	100	1
69.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	35.00	[illegible]	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	[illegible]	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.82
10.00	35.00	[illegible]	5.36
11.00	35.00	[illegible]	7.02
12.00	35.00	[illegible]	8.88
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.10
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	20.13
18.00	35.00	[illegible]	23.06
19.00	35.00	[illegible]	24.96
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.01

T1= 0. T2= .0

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.15
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.06
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.06
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.06
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06
46.00	35.00	[illegible]	36.47
47.00	35.00	[illegible]	37.33
48.00	35.00	[illegible]	38.19
49.00	35.00	[illegible]	39.92
50.00	35.00	[illegible]	42.19
51.00	35.00	[illegible]	44.73
52.00	35.00	[illegible]	47.5[illegible]

53.00	35.00	[illegible]	50.22
54.00	35.00	[illegible]	51.93
55.00	35.00	[illegible]	53.64
56.00	35.00	[illegible]	55.35
57.00	35.00	[illegible]	56.51
58.00	35.00	[illegible]	57.66
59.00	35.00	[illegible]	58.46
60.00	35.00	[illegible]	59.34
61.00	35.00	[illegible]	60.10
62.00	35.00	[illegible]	60.57
63.00	35.00	[illegible]	60.81
64.00	35.00	[illegible]	60.96
65.00	35.00	[illegible]	61.19
66.00	35.00	[illegible]	61.31
67.00	35.00	[illegible]	61.53
68.00	35.00	[illegible]	61.76
69.00	35.00	[illegible]	61.98
70.00	35.00	[illegible]	62.2[illegible]
71.00	35.00	[illegible]	62.27
72.00	35.00	[illegible]	62.33
73.00	35.00	[illegible]	62.82
74.00	35.00	[illegible]	63.3[illegible]
75.00	35.00	[illegible]	64.58
76.00	35.00	[illegible]	65.87
77.00	35.00	[illegible]	66.63
78.00	35.00	[illegible]	68.49
79.00	35.00	[illegible]	70.35
80.00	35.00	[illegible]	72.21
81.00	35.00	[illegible]	74.07
82.00	35.00	[illegible]	75.74
83.00	35.00	[illegible]	77.41
84.00	35.00	[illegible]	79.07
85.00	35.00	[illegible]	79.36
86.00	35.00	[illegible]	79.64
87.00	35.00	[illegible]	79.95
88.00	35.00	[illegible]	80.16
89.00	35.00	[illegible]	80.36
90.00	35.00	[illegible]	80.43
91.00	35.00	[illegible]	80.43
92.00	35.00	[illegible]	80.43
93.00	35.00	[illegible]	80.43
94.00	35.00	[illegible]	80.43
95.00	35.00	[illegible]	80.43
96.00	35.00	[illegible]	80.43
97.00	35.00	[illegible]	80.43
98.00	35.00	[illegible]	80.43
99.00	35.00	[illegible]	80.43
100.00	35.00	[illegible]	80.43

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
61.00	3[illegible].00	100	1
7[illegible].00	44.00	100	1
18.00	[illegible]3.00	100	1
55.00	54.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	35.00	100	1
59.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
6[illegible].00	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	55.00	100	1
57.00	5[illegible].00	100	1
38.00	17.00	100	1
55.00	15.00	100	1
18.00	13.00	100	1
36.00	2[illegible].00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	59.00	100	1
76.00	58.00	100	1

9[illegible].00	49.00	100	1
76.00	18.00	100	1
9[illegible].00	52.00	100	1
45.00	54.00	100	1
6[illegible].00	2.00	100	1
65.00	15.00	100	1
69.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	35.00	[illegible]	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	[illegible]	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.82
10.00	35.00	[illegible]	5.36
11.00	35.00	[illegible]	7.02
12.00	35.00	[illegible]	8.88
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.10
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	20.13
18.00	35.00	[illegible]	23.08
19.00	35.00	[illegible]	24.96
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.01

T1= 0.[illegible]T2= [illegible]

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.13
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.06
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.06
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.06
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06
46.00	35.00	[illegible]	36.89
47.00	35.00	[illegible]	37.75
48.00	35.00	[illegible]	39.61
49.00	35.00	[illegible]	40.34
50.00	35.00	[illegible]	42.01
51.00	35.00	[illegible]	45.13
52.00	35.00	[illegible]	47.92

53.00	35.00	[illegible]	52.63
54.00	35.00	[illegible]	52.65
55.00	35.00	[illegible]	53.89
56.00	35.00	[illegible]	55.14
T1= [illegible] T2= [illegible]			
57.00	35.00	[illegible]	55.78
58.00	35.00	[illegible]	56.57
59.00	35.00	[illegible]	57.37
60.00	35.00	[illegible]	58.26
61.00	35.00	[illegible]	59.01
62.00	35.00	[illegible]	59.48
63.00	35.00	[illegible]	59.72
64.00	35.00	[illegible]	59.86
65.00	35.00	[illegible]	60.[illegible]
66.00	35.00	[illegible]	60.36
67.00	35.00	[illegible]	60.58
68.00	35.00	[illegible]	60.81
69.00	35.00	[illegible]	61.03
70.00	35.00	[illegible]	61.29
71.00	35.00	[illegible]	61.32
72.00	35.00	[illegible]	61.38
73.00	35.00	[illegible]	61.87
74.00	35.00	[illegible]	62.35
75.00	35.00	[illegible]	63.63
76.00	35.00	[illegible]	64.92
77.00	35.00	[illegible]	65.68
78.00	35.00	[illegible]	67.54
79.00	35.00	[illegible]	69.40
80.00	35.00	[illegible]	71.26
81.00	35.00	[illegible]	73.12
82.00	35.00	[illegible]	74.79
83.00	35.00	[illegible]	75.46
84.00	35.00	[illegible]	78.12
85.00	35.00	[illegible]	78.41
86.00	35.00	[illegible]	78.69
87.00	35.00	[illegible]	79.00
88.00	35.00	[illegible]	79.21
89.00	35.00	[illegible]	79.41
90.00	35.00	[illegible]	79.48
91.00	35.00	[illegible]	79.48
92.00	35.00	[illegible]	79.48
93.00	35.00	[illegible]	79.48
94.00	35.00	[illegible]	79.48
95.00	35.00	[illegible]	79.48
96.00	35.00	[illegible]	79.48
97.00	35.00	[illegible]	79.48
98.00	35.00	[illegible]	79.48
99.00	35.00	[illegible]	79.48
100.00	35.00	[illegible]	79.48

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	30.00	100	1
70.00	44.00	100	1
18.00	43.00	100	1
55.00	47.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	37.50	100	1
69.00	49.00	100	1
37.00	52.00	100	1
15.00	49.00	100	1
39.00	54.00	100	1
5[illegible].00	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	55.00	100	1
57.00	5[illegible].00	100	1
38.00	17.00	100	1
66.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
64.00	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	59.00	100	1
78.00	58.00	100	1

90.00	49.00	100	1
75.00	16.00	100	1
94.00	12.00	100	1
45.00	34.00	100	1
60.00	2.00	100	1
66.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG([illegible])	EXPOSURE
1.00	35.00	0.0000	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	0.0000	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.63
7.00	35.00	[illegible]	1.26
8.00	35.00	[illegible]	2.53
9.00	35.00	0.0000	3.82
10.00	35.00	0.0000	5.38
11.00	35.00	0.0000	7.02
12.00	35.00	[illegible]	8.88
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.11
16.00	35.00	[illegible]	17.18
17.00	35.00	0.0000	20.13
18.00	35.00	0.0000	23.08
19.00	35.00	[illegible]	24.96
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	0.0000	30.25
23.00	35.00	0.0000	31.21
24.00	35.00	0.0000	32.01

T1= 0.0 T2= 0.0

X-ROTATED	Y-ROTATED	ANG([illegible])	EXPOSURE
25.00	35.00	0.0000	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	0.0000	33.64
28.00	35.00	0.0000	34.39
29.00	35.00	0.0000	35.15
30.00	35.00	0.0000	35.39
31.00	35.00	0.0000	35.64
32.00	35.00	0.0000	35.78
33.00	35.00	0.0000	35.92
34.00	35.00	0.0000	36.06
35.00	35.00	0.0000	36.06
36.00	35.00	0.0000	36.06
37.00	35.00	0.0000	36.06
38.00	35.00	[illegible]	36.06
39.00	35.00	0.0000	36.06
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	35.06
46.00	35.00	[illegible]	36.47
47.00	35.00	[illegible]	37.33
48.00	35.00	[illegible]	38.19
49.00	35.00	[illegible]	39.92
50.00	35.00	[illegible]	42.19
51.00	35.00	[illegible]	44.73
52.00	35.00	[illegible]	47.50

53.00	35.00	0.0000	50.22
54.00	35.00	0.0000	51.93
55.00	35.00	0.0000	53.64
56.00	35.00	0.0000	55.35
57.00	35.00	0.0000	56.51
58.00	35.00	0.0000	57.66
59.00	35.00	0.0000	58.46
60.00	35.00	0.0000	59.34
61.00	35.00	0.0000	60.10
62.00	35.00	0.0000	60.57
63.00	35.00	0.0000	60.81
64.00	35.00	0.0000	60.95
65.00	35.00	0.0000	61.09
66.00	35.00	0.0000	61.31
67.00	35.00	0.0000	61.53
68.00	35.00	0.0000	61.76
69.00	35.00	0.0000	61.98
70.00	35.00	0.0000	62.20
71.00	35.00	0.0000	62.27
72.00	35.00	0.0000	62.33
73.00	35.00	0.0000	62.82
74.00	35.00	0.0000	63.30
75.00	35.00	0.0000	64.58
76.00	35.00	0.0000	65.87
77.00	35.00	0.0000	66.63
78.00	35.00	0.0000	68.49
79.00	35.00	0.0000	70.35
80.00	35.00	0.0000	72.21
81.00	35.00	0.0000	74.07
82.00	35.00	0.0000	75.74
83.00	35.00	0.0000	77.41
84.00	35.00	0.0000	79.07
85.00	35.00	0.0000	79.36
86.00	35.00	0.0000	79.64
87.00	35.00	0.0000	79.95
88.00	35.00	0.0000	80.16
89.00	35.00	0.0000	80.35
90.00	35.00	0.0000	80.43
91.00	35.00	0.0000	80.43
92.00	35.00	0.0000	80.43
93.00	35.00	0.0000	80.43
94.00	35.00	0.0000	80.43
95.00	35.00	0.0000	80.43
96.00	35.00	0.0000	80.43
97.00	35.00	0.0000	80.43
98.00	35.00	0.0000	80.43
99.00	35.00	0.0000	80.43
100.00	35.00	0.0000	80.43

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	3[illegible].00	100	1
7[illegible].00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	4[illegible].00	100	1
69.00	49.00	100	1
27.00	52.00	100	1
1[illegible].00	59.00	100	1
39.00	54.00	100	1
5[illegible].00	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	55.00	100	1
57.00	5[illegible].00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	2[illegible].00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
6[illegible].00	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	59.00	100	1
75.00	58.00	100	1
9[illegible].00	49.00	100	1
75.00	18.00	100	1
9[illegible].00	62.00	100	1
45.00	5[illegible].00	100	1
5[illegible].00	2.00	100	1
65.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(FAC)	EXPOSURE
1.00	35.00	[illegible]	[illegible]
2.00	35.00	[illegible]	[illegible]
3.00	35.00	[illegible]	[illegible]
4.00	35.00	[illegible]	[illegible]
[illegible]	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.62
10.00	35.00	[illegible]	5.38
11.00	35.00	[illegible]	7.02
12.00	35.00	[illegible]	8.66
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.02
15.00	35.00	[illegible]	15.1[illegible]
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	2[illegible].13
18.00	35.00	[illegible]	23.[illegible]
19.00	35.00	[illegible]	24.95
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.01

T1= 0.0T2= [illegible]

X-ROTATED	Y-ROTATED	ANG(FAC)	EXPOSURE
25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.15
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.05
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.06
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.06
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.06
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06

46.00	35.00	0.0000	36.47
47.00	35.00	0.0000	36.92
48.00	35.00	0.0000	37.78
49.00	35.00	0.0000	38.64
50.00	35.00	0.0000	40.91
51.00	35.00	0.0000	43.17
52.00	35.00	0.0000	45.14
53.00	35.00	0.0000	47.98
54.00	35.00	0.0000	50.13
55.00	35.00	0.0000	52.27
56.00	35.00	0.0000	54.42
57.00	35.00	0.0000	56.56
58.00	35.00	0.0000	57.71
59.00	35.00	0.0000	59.35
60.00	35.00	0.0000	59.7[illegible]
61.00	35.00	0.0000	59.92
62.00	35.00	0.0000	60.33
63.00	35.00	0.0000	60.52
64.00	35.00	0.0000	60.66
65.00	35.00	0.0000	60.56
66.00	35.00	0.0000	60.88
67.00	35.00	0.0000	61.11
68.00	35.00	0.0000	61.33
69.00	35.00	0.0000	61.55
70.00	35.00	0.0000	61.77
71.00	35.00	0.0000	61.84
72.00	35.00	0.0000	61.91
73.00	35.00	0.0000	62.39
74.00	35.00	0.0000	62.87
75.00	35.00	0.0000	64.16
76.00	35.00	0.0000	65.44
77.00	35.00	0.0000	66.2[illegible]
78.00	35.00	0.0000	68.06
79.00	35.00	0.0000	69.92
80.00	35.00	0.0000	71.78
81.00	35.00	0.0000	73.64
82.00	35.00	0.0000	75.31
83.00	35.00	0.0000	76.98
84.00	35.00	0.0000	78.64
85.00	35.00	0.0000	78.93
86.00	35.00	0.0000	79.21
87.00	35.00	0.0000	79.52
88.00	35.00	0.0000	79.73
89.00	35.00	[illegible]	79.93
90.00	35.00	[illegible]	80.00
91.[illegible]	35.[illegible]	[illegible]	8[illegible]
92.[illegible]	35.[illegible]	[illegible]	8[illegible]
93.0[illegible]	35.[illegible]	[illegible]	8[illegible]
9[illegible]	35.[illegible]	[illegible]	8[illegible]
9[illegible]	35.[illegible]	[illegible]	8[illegible]
9[illegible]	35.[illegible]	[illegible]	8[illegible]
9[illegible]	35.[illegible]	[illegible]	8[illegible]
9[illegible]	35.[illegible]	[illegible]	8[illegible]
9[illegible]	35.[illegible]	[illegible]	8[illegible]
1[illegible]	35.[illegible]	[illegible]	8[illegible]

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	1.[illegible]	1
53.00	27.00	1.[illegible]	1
24.00	35.00	1[illegible]	1
53.00	42.00	1[illegible]	1
81.00	3[illegible].00	1[illegible]	1
75.00	44.00	1[illegible]	1
18.00	43.00	1[illegible]	1
56.00	44.00	1[illegible]	1
8[illegible].00	43.00	1[illegible]	1
62.00	25.00	1[illegible]	1
56.00	42.00	1[illegible]	1
69.00	49.00	1[illegible]	1
27.00	52.00	1[illegible]	1
15.00	49.00	1[illegible]	1
39.00	54.00	1[illegible]	1
6[illegible].00	18.00	1.[illegible]	1
18.00	2.00	1[illegible]	1
71.00	64.00	10[illegible]	1
94.00	65.00	1[illegible]	1
57.00	5[illegible].00	10[illegible]	1
38.00	17.00	10[illegible]	1
56.00	15.00	1[illegible]	1
18.00	13.00	100	1
36.00	2[illegible].00	1[illegible]	1
67.00	59.00	100	1
47.00	14.00	1.0	1
60.00	6.00	100	1
55.00	22.00	1[illegible]	1
18.00	54.00	1[illegible]	1
83.00	59.00	1[illegible]	1
76.00	58.00	1[illegible]	1
9[illegible].00	49.00	1[illegible]	1
76.00	18.00	1[illegible]	1
94.00	52.00	1[illegible]	1
45.00	5[illegible].00	1	1
6[illegible].00	2.00	1[illegible]	1
66.00	16.00	1.[illegible]	1
89.00	18.00	1.[illegible]	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	35.00	[illegible]	0.00
2.00	35.00	[illegible]	0.00
3.00	35.00	[illegible]	0.00
4.00	35.00	[illegible]	0.00
5.00	35.00	[illegible]	.42
6.00	35.00	[illegible]	.83
7.00	35.00	[illegible]	1.25
8.00	35.00	[illegible]	2.53
9.00	35.00	[illegible]	3.62
10.00	35.00	[illegible]	5.38
11.00	35.00	[illegible]	7.[illegible]2
12.00	35.00	[illegible]	8.88
13.00	35.00	[illegible]	10.74
14.00	35.00	[illegible]	13.62
15.00	35.00	[illegible]	15.10
16.00	35.00	[illegible]	17.18
17.00	35.00	[illegible]	20.13
18.00	35.00	[illegible]	23.[illegible]8
19.00	35.00	[illegible]	24.95
20.00	35.00	[illegible]	26.83
21.00	35.00	[illegible]	28.54
22.00	35.00	[illegible]	30.26
23.00	35.00	[illegible]	31.21
24.00	35.00	[illegible]	32.[illegible]1

T1= 0.0T2= [illegible].0

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
25.00	35.00	[illegible]	32.45
26.00	35.00	[illegible]	33.04
27.00	35.00	[illegible]	33.64
28.00	35.00	[illegible]	34.39
29.00	35.00	[illegible]	35.15
30.00	35.00	[illegible]	35.39
31.00	35.00	[illegible]	35.64
32.00	35.00	[illegible]	35.78
33.00	35.00	[illegible]	35.92
34.00	35.00	[illegible]	36.06
35.00	35.00	[illegible]	36.06
36.00	35.00	[illegible]	36.06
37.00	35.00	[illegible]	36.[illegible]
38.00	35.00	[illegible]	36.06
39.00	35.00	[illegible]	36.05
40.00	35.00	[illegible]	36.06
41.00	35.00	[illegible]	36.06
42.00	35.00	[illegible]	36.06
43.00	35.00	[illegible]	36.16
44.00	35.00	[illegible]	36.06
45.00	35.00	[illegible]	36.06

46.00	35.11	[illegible]	36.47
47.00	35.11	[illegible]	36.92
48.00	35.11	[illegible]	37.36
49.00	35.11	[illegible]	37.81
50.00	35.11	[illegible]	39.01
51.00	35.11	[illegible]	40.22
52.00	35.11	[illegible]	41.64
53.00	35.11	[illegible]	43.07
54.00	35.11	[illegible]	44.34
55.00	35.11	[illegible]	45.61
56.00	35.11	[illegible]	46.87
57.00	35.11	[illegible]	47.29
58.00	35.11	[illegible]	47.71
59.00	35.11	[illegible]	47.97
60.00	35.11	[illegible]	48.17
61.00	35.11	[illegible]	48.24
62.00	35.11	[illegible]	48.53
63.00	35.11	[illegible]	48.53
64.00	35.11	[illegible]	48.53
65.00	35.11	[illegible]	48.53
66.00	35.11	[illegible]	48.75
67.00	35.11	[illegible]	48.97
68.00	35.11	[illegible]	49.19
69.00	35.11	[illegible]	49.42
70.00	35.11	[illegible]	49.64
71.00	35.11	[illegible]	49.71
72.00	35.11	[illegible]	49.77
73.00	35.11	[illegible]	50.26
74.00	35.11	[illegible]	50.74
75.00	35.11	[illegible]	52.02
76.00	35.11	[illegible]	53.31
77.00	35.11	[illegible]	54.07
78.00	35.11	[illegible]	55.93
79.00	35.11	[illegible]	57.79
80.00	35.11	[illegible]	59.65
81.00	35.11	[illegible]	61.51
82.00	35.11	[illegible]	63.18
83.00	35.11	[illegible]	64.84
84.00	35.11	[illegible]	66.51
85.00	35.11	[illegible]	66.79
86.00	35.11	[illegible]	67.08
87.00	35.11	[illegible]	67.39
88.00	35.11	[illegible]	67.59
89.00	35.11	[illegible]	67.80
90.00	35.11	[illegible]	67.87
91.00	35.11	[illegible]	67.87
92.00	35.11	[illegible]	67.87
93.00	35.11	[illegible]	67.87
94.00	35.11	[illegible]	67.87
95.00	35.11	[illegible]	67.87
96.00	35.11	[illegible]	67.87
97.00	35.11	[illegible]	67.87
98.00	35.11	[illegible]	67.87
99.00	35.11	[illegible]	67.87
100.00	35.11	[illegible]	67.87

Appendix C3

Automatic Model Output

(see Table 3, 1 KM Column)

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OPTIMUM FLIGHT PATH INPUT SUMMARY---

CHECKPT 1--   [illegible],  35.[illegible]     A/C VELOCITY--MIN=648.[illegible]     CORRIDOR WIDTH= 2[illegible].
        2-- 1[illegible].00[illegible],  35.[illegible]                      MAX=722.[illegible]       AWARE RADIUS= 2[illegible].

NRAYS=11     NO STEPS=25     NO SITES= 38     NO SITE TYPES=    1

NO. OF MEASUREMENTS=    1     SIGMA(RANGE)=      [illegible]     SIGMA(ANGLE)=       .[illegible] DEG.


PK DATA--EACH SITE TYPE


    SITE TYPE=  1[illegible]     SITE TYPE NO= 1

        COLUMNS=RINGS,ROWS=SECTORS
 .133        .125        .117        .[illegible]79
 .272        .217        .172        .1[illegible]7
 .281        .295        .25[illegible]        .136
 .231        .137        .133        .[illegible]
 .075        .34[illegible]        .112        .[illegible]25
```

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	34.00	100	1
70.00	44.00	100	1
18.00	43.00	100	1
56.00	[illegible]	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	27.50	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	54.00	100	1
65.00	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	65.00	100	1
57.00	5[illegible].00	100	1
38.00	17.00	100	1
55.00	15.00	100	1
18.00	13.00	100	1
36.00	2[illegible].00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	59.00	100	1
75.00	58.00	100	1
9[illegible].00	49.00	100	1
78.00	18.00	100	1
94.00	52.00	100	1
45.00	54.00	100	1
6[illegible].00	2.00	100	1
66.00	16.00	100	1
69.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	34.51	-.4570	0.00
2.00	34.12	-.4570	0.00
3.00	33.52	-.4570	0.00
4.00	33.13	-.4570	0.00
5.00	32.54	-.4570	0.00
6.00	32.15	-.4570	0.00
7.00	31.55	-.4570	0.00
8.00	31.17	-.4570	.22
9.00	30.57	-.4570	.44
10.00	30.13	-.4570	.51
11.00	29.53	-.4570	.58
12.00	29.10	-.4570	.58
13.00	28.51	-.4570	.58
14.00	28.51	-.[illegible]	.58
15.00	28.51	-.[illegible]	.58
16.00	28.12	-.4570	.56
17.00	28.21	.0914	.99
18.00	28.31	.0914	1.41
19.00	28.73	.4570	2.69
20.00	28.73	-.[illegible]	3.46
21.00	28.73	-.[illegible]	4.22
22.00	28.73	-.[illegible]	4.98
23.00	28.33	.0914	5.74
24.00	28.37	.0914	6.50
25.00	28.4[illegible]	.4570	8.14
26.00	28.55	.0914	9.58
27.00	29.55	.0914	9.80
28.00	30.14	.4570	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.00	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.37	.1828	10.79
34.00	31.55	.1828	10.79
35.00	31.74	.1828	10.79
36.00	31.92	.1828	10.79
37.00	32.11	.1828	10.79
38.00	32.29	.1828	10.79
39.00	32.48	.1828	10.79
40.00	32.66	.1828	10.79
41.00	32.85	.1828	10.79
42.00	33.03	.1828	10.79
43.00	33.22	.1828	10.79
44.00	33.40	.1828	10.79

45.00	33.53	.1828	10.79
46.00	33.37	.2742	11.02
47.00	34.05	.1828	11.65
48.00	34.44	.3656	12.29
49.00	34.34	-.0914	13.16
50.00	34.25	-.0914	14.56
51.00	34.15	-.0914	15.76
52.00	34.07	-.0914	18.44
53.00	34.15	.0914	19.75
54.00	34.07	-.0914	20.98
55.00	33.33	-.0914	22.02
56.00	33.33	[illegible]	23.07
57.00	33.43	-.4571	24.60
58.00	33.77	.2742	25.24
59.00	33.95	.1828	25.82
60.00	34.14	.1828	26.40
61.00	34.52	.3656	26.61
62.00	34.61	.0914	26.81
63.00	34.73	.0914	26.88
64.00	34.79	.0914	26.94
65.00	34.39	.0914	26.94
66.00	34.33	.0914	27.17
67.00	34.49	-.4571	27.23
68.00	33.93	-.4571	27.23
69.00	34.13	.1828	27.46
70.00	33.53	-.4571	27.46
71.00	33.41	-.2742	27.46
72.00	33.12	-.2742	27.87
73.00	32.94	-.1828	28.29
74.00	32.55	-.2742	29.57
75.00	32.33	-.2742	30.86
76.00	32.10	-.2742	32.42
77.00	31.51	-.4571	33.98
78.00	31.42	-.1828	35.49
79.00	31.23	-.1828	37.[illegible]
80.00	31.05	-.1828	37.74
81.00	31.43	.3656	38.39
82.00	31.71	.2742	38.83
83.00	31.91	.1828	39.42
84.00	32.23	.3656	40.02
85.00	32.77	.4571	40.77
86.00	32.35	.1828	41.53
87.00	33.34	.3656	41.77
88.00	33.72	.3656	42.02
89.00	34.11	.3656	42.16
90.00	34.51	.4571	42.16
91.00	35.03	[illegible]	42.16
92.00	[illegible]	[illegible]	42.16
93.00	[illegible]	[illegible]	42.16
94.00	[illegible]	[illegible]	42.16
95.00	[illegible]	[illegible]	42.16
96.00	[illegible]	[illegible]	42.16
97.00	[illegible]	[illegible]	42.16
98.00	[illegible]	[illegible]	42.16
99.00	[illegible]	[illegible]	42.16
100.00	34.51	-.4571	42.16

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	1.00	1
53.00	27.00	1.00	1
24.00	34.00	1.00	1
53.00	42.00	1.00	1
81.00	3[illegible].00	1.00	1
7[illegible].00	44.00	1.00	1
18.00	43.00	1.00	1
58.00	46.00	1.00	1
84.00	43.00	1.00	1
62.00	25.00	1.00	1
56.00	3[illegible].00	1.00	1
69.00	49.00	1.00	1
27.00	52.00	1.00	1
15.00	49.00	1.00	1
39.00	56.00	1.00	1
6[illegible].00	18.00	1.00	1
18.00	2.00	1.00	1
71.00	54.00	1.00	1
94.00	65.00	1.00	1
57.00	5[illegible].00	1.00	1
38.00	17.00	1.00	1
55.00	15.00	1.00	1
18.00	13.00	1.00	1
35.00	2[illegible].00	1.00	1
67.00	59.00	1.00	1
47.00	14.00	1.00	1
60.00	6.00	1.00	1
55.00	22.00	1.00	1
18.00	5[illegible].00	1.00	1
83.00	59.00	1.00	1
76.00	58.00	1.00	1
9[illegible].00	49.00	1.00	1
75.00	18.00	1.00	1
94.00	52.00	1.00	1
4[illegible].00	5[illegible].00	1.00	1
6[illegible].00	2.00	1.00	1
65.00	16.00	1.00	1
69.00	18.00	1.00	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	34.51	-.4571	0.00
2.00	34.12	-.4571	0.00
3.00	33.52	-.4571	0.00
4.00	33.13	-.4571	0.00
5.00	32.54	-.4571	0.00
6.00	32.15	-.4571	0.00
7.00	31.55	-.4571	0.00
8.00	31.17	-.4571	.22
9.00	30.57	-.4571	.44
10.00	30.33	-.4571	.51
11.00	29.53	-.4571	.58
12.00	29.13	-.4571	.58
13.00	28.51	-.4571	.58
14.00	28.51	-.[illegible]	.58
15.00	28.51	-.[illegible]	.56
16.00	28.12	-.4571	.58
17.00	28.21	.0914	.99
18.00	28.33	.0914	1.41
19.00	28.73	.4571	2.69
20.00	28.73	-.[illegible]	3.46
21.00	28.73	-.[illegible]	4.22
22.00	28.73	-.[illegible]	4.98
23.00	28.33	.0914	5.74
24.00	28.37	.0914	6.53
25.00	28.47	.4571	8.14
26.00	28.55	.0914	9.58
27.00	28.55	.0914	9.80
28.00	30.14	.4571	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.00	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.57	.4571	10.72
34.00	32.17	.4571	10.72
35.00	32.35	.1828	10.72
36.00	32.54	.1828	10.72
37.00	32.72	.1828	10.72
38.00	32.91	.1828	10.72
39.00	33.13	.1828	10.72
40.00	33.23	.1828	10.72
41.00	33.45	.1828	10.72
42.00	33.55	.1828	10.72
43.00	33.33	.1828	10.72
44.00	33.92	.1828	10.72
45.00	34.20	.1828	10.72

46.00	34.59	.4570	10.72
47.00	34.73	.0914	11.17
48.00	34.83	.0914	12.03
49.00	34.97	.0914	12.69
50.00	35.05	.0914	14.63
51.00	35.15	.0914	16.38
52.00	35.24	.0914	18.34
53.00	35.24	-.[illegible]	20.31
54.00	35.24	-.[illegible]	22.46
55.00	35.24	-.[illegible]	24.60
56.00	35.24	-.[illegible]	26.74
57.00	34.75	-.4570	29.06
58.00	34.84	.0914	30.30
59.00	34.93	.0914	31.94
60.00	35.12	.1828	32.32
61.00	35.51	.4570	32.63
62.00	35.33	-.2742	32.70
63.00	35.05	-.2742	32.77
64.00	35.14	.0914	32.91
65.00	35.23	.0914	32.91
66.00	35.32	.0914	33.13
67.00	34.33	-.4570	33.19
68.00	34.34	-.4570	33.26
69.00	33.35	-.4570	33.25
70.00	33.35	-.4570	33.26
71.00	33.35	.4570	33.25
72.00	33.57	-.2742	33.68
73.00	33.23	-.2742	34.09
74.00	33.00	-.2742	35.38
75.00	32.72	-.2742	36.66
76.00	32.44	-.2742	38.22
77.00	31.95	-.4570	39.78
78.00	31.57	-.2742	41.29
79.00	31.39	-.2742	42.81
80.00	31.11	-.2742	43.54
81.00	31.49	.3656	44.19
82.00	31.11	-.3656	44.84
83.00	31.29	.1828	45.44
84.00	31.73	.4570	46.03
85.00	32.27	.4570	46.79
86.00	32.77	.4570	47.54
87.00	33.25	.4570	47.79
88.00	33.54	.3656	48.03
89.00	34.12	.3656	48.17
90.00	34.51	.4570	48.17
91.00	[illegible]	.4570	48.17
92.00	[illegible]	-.[illegible]	48.17
93.00	[illegible]	-.[illegible]	48.17
94.00	[illegible]	-.[illegible]	48.17
95.00	[illegible]	-.[illegible]	48.17
96.00	[illegible]	-.[illegible]	48.17
97.00	[illegible]	-.[illegible]	48.17
98.00	[illegible]	-.[illegible]	48.17
99.00	[illegible]	-.[illegible]	48.17
100.00	[illegible].31	-.[illegible]	48.17

SITE DATA---

	X-ROTATED	Y-ROTATED		
	14.00	39.00	1.00	1
	[illegible]3.00	27.00	1.00	1
	24.00	35.00	1.00	1
	53.00	42.00	1.00	1
	81.00	3[illegible].00	1.00	1
	7[illegible].00	[illegible]	1.00	1
	18.00	43.00	1.00	1
	56.00	44.00	1.00	1
	84.00	43.00	1.00	1
	62.00	25.00	1.00	1
	[illegible]8.00	32.5[illegible]	1.00	1
	69.00	49.00	1.00	1
	27.00	52.00	1.00	1
	15.00	49.00	1.00	1
	39.00	54.00	1.00	1
	6[illegible].00	18.00	1.00	1
	18.00	2.00	1.00	1
	71.00	54.00	1.00	1
	94.00	55.00	1.00	1
	57.00	5[illegible].00	1.00	1
	38.00	17.00	1.00	1
	56.00	15.00	1.00	1
	18.00	13.00	1.00	1
	36.00	24.00	1.00	1
	67.00	59.00	1.00	1
	47.00	14.00	1.00	1
	66.00	6.00	1.00	1
	55.00	22.00	1.00	1
	18.00	54.00	1.00	1
	83.00	59.00	1.00	1
	78.00	58.00	1.00	1
	9[illegible].00	49.00	1.00	1
	76.00	19.00	1.00	1
	94.00	52.00	1.00	1
	45.00	[illegible]	1.00	1
	6[illegible].00	2.00	1.00	1
	65.00	16.00	1.00	1
	89.00	18.00	1.00	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	33.51	-.4571	0.00
2.00	34.12	-.4571	0.00
3.00	33.32	-.4571	0.00
4.00	33.13	-.4571	0.00
5.00	32.54	-.4571	0.00
6.00	32.35	-.4571	0.00
7.00	31.75	-.4571	0.00
8.00	31.17	-.4571	.22
9.00	31.57	-.4571	.44
10.00	30.78	-.4571	.51
11.00	29.59	-.4571	.58
12.00	29.11	-.4571	.58
13.00	29.51	-.4571	.58
14.00	29.51	-.4571	.58
15.00	29.51	[illegible]	.58
16.00	29.12	-.4571	.58
17.00	29.21	.0914	.99
18.00	29.30	.0914	1.41
19.00	29.79	.4571	2.69
20.00	29.79	[illegible]	3.46
21.00	29.79	[illegible]	4.22
22.00	29.79	-.1828	4.98
23.00	29.33	.0914	5.74
24.00	29.37	.0914	6.50
25.00	29.47	.4571	8.14
26.00	29.55	.0914	9.58
27.00	29.55	.0914	9.89
28.00	30.14	.4571	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.00	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.57	.4571	10.72
34.00	32.17	.4571	10.72
35.00	32.25	.0914	10.72
36.00	32.35	.0914	10.72
37.00	32.44	.0914	10.72
38.00	32.53	.0914	10.72
39.00	32.04	-.4571	10.72
40.00	32.13	.0914	10.72
41.00	32.22	.0914	10.72
42.00	32.32	.0914	10.72
43.00	32.41	.0914	10.72
44.00	32.50	.0914	10.72
45.00	32.59	.0914	11.14

46.00	32.97	.3656	11.36
47.00	33.[illegible]	.[illegible]91[illegible]	12.[illegible]
48.00	33.45	.3656	13.[illegible]5
49.00	33.45	-.[illegible]	15.32
50.00	33.45	-.[illegible]	17.59
51.00	33.45	-.[illegible]	20.13
52.00	33.45	-.[illegible]	22.68
53.00	33.45	-.[illegible]	25.17
54.00	33.45	-.[illegible]	26.97
55.00	33.45	-.[illegible]	27.93
56.00	33.45	-.[illegible]	28.97
57.00	32.95	-.4570	30.39
58.00	33.24	.2742	31.45
59.00	33.52	.2742	32.41
60.00	33.31	.2742	33.37
61.00	34.13	.3656	34.19
62.00	34.23	.[illegible]914	34.5[illegible]
63.00	34.37	.[illegible]914	34.81
64.00	34.45	.[illegible]914	35.[illegible]2
65.00	34.55	.[illegible]914	35.16
66.00	34.54	.[illegible]914	35.16
67.00	34.15	-.4570	35.16
68.00	33.55	-.457	35.16
69.00	33.34	.1828	35.16
70.00	33.35	-.457[illegible]	35.16
71.00	33.34	.457[illegible]	35.16
72.00	33.55	-.2742	35.57
73.00	33.23	-.2742	35.99
74.00	33.[illegible]	-.2742	37.27
75.00	32.72	-.2742	38.56
76.00	32.44	-.2742	40.12
77.00	31.95	-.457[illegible]	41.68
78.00	31.55	-.2742	43.19
79.00	31.33	-.2742	44.7[illegible]
80.00	31.10	-.2742	45.44
81.00	31.43	.3656	45.[illegible]9
82.00	31.77	.2742	46.68
83.00	31.95	.1828	47.28
84.00	32.14	.1828	47.57
85.00	32.53	.457[illegible]	48.63
86.00	33.31	.3656	49.38
87.00	33.[illegible]3	.3656	49.63
88.00	33.73	.3656	49.87
89.00	34.15	.3656	5[illegible].01
90.00	34.55	.4570	5[illegible].01
91.00	35.14	.4570	5[illegible].01
92.00	35.14	-.[illegible]	5[illegible].01
93.00	35.14	-.[illegible]	5[illegible].01
94.00	35.14	-.[illegible]	5[illegible].01
95.00	35.14	-.[illegible]	5[illegible].01
96.00	35.14	-.[illegible]	5[illegible].01
97.00	35.14	-.[illegible]	5[illegible].01
98.00	35.[illegible]5	-.[illegible]914	5[illegible].01
99.00	35.[illegible]5	-.[illegible]	5[illegible].01
100.00	34.55	-.[illegible]	5[illegible].01

SITE DATA---

X-ROTATED Y-ROTATED

14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	3[illegible].00	100	1
7[illegible].00	44.00	100	1
18.00	43.00	100	1
56.00	40.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	35.00	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	54.00	100	1
6[illegible].00	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	55.00	100	1
57.00	5[illegible].00	100	1
38.00	17.00	100	1
55.00	15.00	100	1
18.00	13.00	100	1
36.00	2[illegible].00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	5[illegible].00	100	1
83.00	59.00	100	1
76.00	58.00	100	1
96.00	49.00	100	1
76.00	18.00	100	1
94.00	52.00	100	1
45.00	5[illegible].00	100	1
6[illegible].00	2.00	100	1
66.00	1[illegible].00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	34.51	-.4571	[illegible]
2.00	34.12	-.4571	[illegible]
3.00	33.52	-.4571	[illegible]
4.00	33.13	-.4571	0.00
5.00	32.54	-.4571	0.00
6.00	32.35	-.4571	[illegible]
7.00	31.55	-.4571	[illegible]
8.00	31.[illegible]7	-.4571	.22
9.00	30.57	-.4571	.44
10.00	30.[illegible]3	-.4571	.51
11.00	29.53	-.4571	.58
12.00	29.13	-.4571	.58
13.00	28.51	-.4571	.58
14.00	28.51	-.[illegible]	.58
15.00	28.51	-.[illegible]	.58
16.00	28.12	-.4571	.58
17.00	28.21	.0914	.99
18.00	28.3[illegible]	.0914	1.41
19.00	28.73	.4571	2.69
20.00	28.73	-.[illegible]	3.46
21.00	28.73	-.[illegible]	4.22
22.00	28.73	-.[illegible]	4.98
23.00	28.33	.0914	5.74
24.00	28.37	.0914	6.59
25.00	28.47	.4571	8.14
26.00	28.55	.0914	9.58
27.00	28.55	.0914	9.80
28.00	30.14	.4571	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.11	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.57	.4571	10.72
34.00	32.17	.4571	10.72
35.00	32.25	.0914	10.72
36.00	32.35	.0914	10.72
37.00	32.44	.0914	10.72
38.00	32.53	.0914	10.72
39.00	32.[illegible]4	-.4571	10.72
40.00	32.13	.0914	10.72
41.00	32.22	.0914	10.72
42.00	32.32	.0914	10.72
43.00	32.41	.0914	10.72
44.00	32.53	.1828	10.72
45.00	32.73	.1828	10.94

46.00	33.15	.3656	11.17
47.00	33.23	.0914	11.81
48.00	33.54	.3656	12.86
49.00	33.54	-.0000	15.13
50.00	33.54	-.0000	17.39
51.00	33.54	[illegible]	19.94
52.00	33.73	.0914	22.48
53.00	33.73	[illegible]	24.98
54.00	33.73	[illegible]	25.77
55.00	33.73	[illegible]	27.75
56.00	33.73	-.0000	28.73
57.00	33.34	-.3656	29.94
58.00	33.53	.1828	31.32
59.00	33.71	.1828	32.28
60.00	33.33	.1828	33.39
61.00	34.23	.3656	34.22
62.00	34.37	.0914	34.53
63.00	34.45	.0914	34.64
64.00	34.55	.0914	35.04
65.00	34.55	.0914	35.18
66.00	34.74	.0914	35.18
67.00	34.23	-.4570	35.18
68.00	33.75	-.4570	35.18
69.00	33.94	.1828	35.18
70.00	33.45	-.4570	35.18
71.00	33.94	.4570	35.18
72.00	33.55	-.2742	35.61
73.00	33.33	-.2742	36.02
74.00	33.11	-.2742	37.30
75.00	32.32	-.2742	38.58
76.00	32.53	-.2742	40.14
77.00	32.14	-.4570	41.71
78.00	31.35	-.1828	43.22
79.00	31.77	-.0914	44.73
80.00	31.57	-.0914	45.42
81.00	31.57	[illegible]	46.12
82.00	31.35	.1828	47.07
83.00	32.24	.3656	47.67
84.00	32.53	.3656	48.26
85.00	33.12	.4570	49.24
86.00	33.41	.2742	49.71
87.00	33.53	.2742	50.02
88.00	33.35	.2742	50.22
89.00	34.24	.2742	50.36
90.00	34.73	.4570	50.36
91.00	35.23	.4570	50.36
92.00	35.23	[illegible]	50.36
93.00	35.23	[illegible]	50.36
94.00	35.23	[illegible]	50.36
95.00	35.23	-.0000	50.35
96.00	35.23	[illegible]	50.36
97.00	35.13	-.0914	50.36
98.00	35.13	[illegible]	50.35
99.00	35.[illegible]4	-.0914	50.36
100.00	34.55	-.457	50.36

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	2[illegible].00	100	1
26.00	35.00	100	1
53.00	42.00	100	1
81.00	30.00	100	1
7[illegible].00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	35.00	100	1
55.00	37.50	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	56.00	100	1
60.00	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	65.00	100	1
57.00	50.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
35.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	59.00	100	1
76.00	58.00	100	1
9[illegible].00	49.00	100	1
78.00	18.00	100	1
94.00	32.00	100	1
45.00	[illegible]	100	1
6[illegible].00	2.00	100	1
96.00	1[illegible].00	100	1
89.00	1[illegible].00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	34.51	-.4570	0.00
2.00	34.12	-.4570	0.00
3.00	33.52	-.457	0.00
4.00	33.13	-.4570	0.00
5.00	32.54	-.4570	0.00
6.00	32.15	-.4570	0.00
7.00	31.55	-.457	0.00
8.00	31.37	-.4570	.22
9.00	30.57	-.4570	.44
10.00	30.13	-.4570	.51
11.00	29.53	-.4570	.58
12.00	29.13	-.4570	.58
13.00	28.51	-.4570	.58
14.00	28.51	[illegible]	.58
15.00	28.51	[illegible]	.58
16.00	28.12	-.4570	.58
17.00	28.21	.0914	.99
18.00	28.31	.0914	1.41
19.00	28.73	.4570	2.69
20.00	28.73	[illegible]	3.46
21.00	28.73	[illegible]	4.22
22.00	28.73	[illegible]	4.98
23.00	28.83	.0914	5.74
24.00	28.87	.0914	6.50
25.00	29.47	.4570	8.14
26.00	29.55	.0914	9.58
27.00	29.55	.0914	9.80
28.00	30.14	.4570	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.03	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.37	.1828	10.79
34.00	31.55	.1828	10.79
35.00	31.74	.1828	10.79
36.00	31.55	-.1828	10.79
37.00	31.45	-.0914	10.79
38.00	31.25	-.1828	10.79
39.00	31.45	.1828	10.79
40.00	31.55	.1828	10.79
41.00	31.33	.1828	10.79
42.00	30. 2	.1828	10.79
43.00	30.23	.1828	10.79
44.00	30.39	.1828	10.79
45.00	30.57	.1828	11.02

46.00	33.35	.3656	11.24
47.00	33.14	.1828	11.46
48.00	33.52	.3656	12.52
49.00	33.51	.0914	13.92
50.00	33.73	.0914	15.18
51.00	33.73	[illegible]	18.45
52.00	33.73	[illegible]	20.99
53.00	33.73	[illegible]	23.62
54.00	33.73	[illegible]	25.54
55.00	33.73	[illegible]	27.03
56.00	33.73	[illegible]	28.52
57.00	33.32	-.3656	30.73
58.00	33.51	.1828	32.61
59.00	33.52	.1828	34.41
60.00	33.33	.1828	36.22
61.00	33.33	-.457	36.68
62.00	33.23	-.0914	37.15
63.00	32.33	-.4570	38.05
64.00	32.33	.1828	38.26
65.00	33.17	.1828	38.46
66.00	33.35	.1828	38.53
67.00	32.35	-.4570	38.59
68.00	32.53	-.2742	38.66
69.00	32.33	-.457	38.73
70.00	32.53	.4570	38.73
71.00	32.43	-.0914	38.73
72.00	32.31	-.1828	39.14
73.00	32.12	-.1828	39.56
74.00	31.34	-.1828	40.84
75.00	31.75	-.1828	42.13
76.00	31.57	-.1828	43.69
77.00	32.15	.4570	45.33
78.00	31.37	-.1828	46.84
79.00	31.73	-.0914	48.35
80.00	31.53	-.0914	49.04
81.00	31.53	[illegible]	49.74
82.00	31.37	.1828	50.69
83.00	32.25	.3656	51.29
84.00	32.54	.3656	51.88
85.00	33.13	.4570	52.66
86.00	33.41	.2742	53.33
87.00	33.53	.2742	53.64
88.00	33.93	.2742	53.84
89.00	34.25	.2742	53.98
90.00	34.75	.4570	53.98
91.00	35.24	.4570	53.98
92.00	35.24	[illegible]	53.98
93.00	35.24	[illegible]	53.98
94.00	35.24	[illegible]	53.98
95.00	35.24	[illegible]	53.98
96.00	35.15	-.0914	53.98
97.00	35.15	[illegible]	53.98
98.00	[illegible]	-.0914	53.98
99.00	[illegible]	[illegible]	53.98
100.00	34.57	-.4570	53.98

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	[illegible]	100	1
[illegible]	[illegible]	100	1
18.00	43.00	100	1
56.00	46.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
58.00	[illegible]	100	1
69.00	[illegible]	100	1
27.00	52.00	100	1
15.00	[illegible]	100	1
39.00	54.00	100	1
[illegible]	18.00	100	1
18.00	2.00	100	1
71.00	54.00	100	1
94.00	55.00	100	1
57.00	51.00	100	1
38.00	17.00	100	1
55.00	15.00	100	1
18.00	13.00	100	1
36.00	[illegible]	100	1
67.00	59.00	100	1
47.00	14.00	100	1
[illegible]	6.00	100	1
55.00	22.00	100	1
18.00	54.00	100	1
83.00	59.00	100	1
76.00	58.00	100	1
90.00	49.00	100	1
76.00	18.00	100	1
94.00	52.00	100	1
45.00	54.00	100	1
[illegible]	2.00	100	1
66.00	15.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	34.51	-.457	0.00
2.00	34.02	-.4571	0.00
3.00	33.52	-.4571	0.00
4.00	33.03	-.4571	0.00
5.00	32.54	-.4571	0.00
6.00	32.05	-.4571	0.00
7.00	31.55	-.4571	0.00
8.00	31.07	-.4571	.22
9.00	30.57	-.4571	.44
10.00	30.08	-.4571	.51
11.00	29.53	-.4571	.58
12.00	29.10	-.4571	.58
13.00	29.51	-.457	.58
14.00	29.51	[illegible]	.59
15.00	29.51	[illegible]	.58
16.00	29.12	-.4571	.58
17.00	29.21	.0914	.99
18.00	29.30	.0914	1.41
19.00	29.73	.4571	2.69
20.00	29.73	[illegible]	3.45
21.00	29.73	[illegible]	4.22
22.00	29.73	[illegible]	4.98
23.00	29.83	.0914	5.74
24.00	29.97	.0914	6.55
25.00	29.47	.4571	8.14
26.00	29.55	.0914	9.58
27.00	29.55	.0914	9.83
28.00	30.14	.4570	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.01	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.37	.1828	10.79
34.00	31.45	.0914	10.79
35.00	31.55	.0914	10.79
36.00	31.54	.0914	10.79
37.00	31.73	.0914	10.79
38.00	31.83	.0914	10.79
39.00	31.92	.0914	10.79
40.00	32.01	.0914	10.79
41.00	32.10	.0914	10.79
42.00	32.13	.0914	10.79
43.00	32.23	.0914	10.79
44.00	32.33	.0914	10.79
45.00	32.47	.0914	11.21

46.00	32.55	.0914	11.63
47.00	32.55	.0914	11.85
48.00	32.74	.0914	12.61
49.00	32.83	.0914	13.37
50.00	32.93	.0914	14.77
51.00	33.12	.0914	15.98
52.00	33.12	-.[illegible]	17.18
53.00	33.12	-.[illegible]	18.93
54.00	33.12	-.[illegible]	19.97
55.00	33.12	-.[illegible]	21.02
56.00	33.12	-.[illegible]	22.06
57.00	33.32	-.[illegible]	22.78
58.00	33.33	.2742	23.36
59.00	33.53	.2742	23.94
60.00	33.85	.2742	24.36
61.00	34.24	.3656	24.64
62.00	34.34	.0914	24.78
63.00	34.13	.0914	24.93
64.00	34.52	.0914	25.19
65.00	34.51	.0914	25.19
66.00	34.71	.0914	25.19
67.00	34.21	-.4570	25.19
68.00	33.72	-.4570	25.19
69.00	33.31	.1828	25.19
70.00	33.41	-.4570	25.19
71.00	33.31	.4570	25.19
72.00	33.52	-.2742	25.61
73.00	33.34	-.2742	26.02
74.00	33.05	-.2742	27.31
75.00	32.73	-.2742	28.59
76.00	32.51	-.2742	30.15
77.00	32.01	-.4570	31.71
78.00	31.91	-.0914	33.22
79.00	31.32	-.0914	34.73
80.00	31.73	-.0914	35.43
81.00	31.73	-.[illegible]	36.12
82.00	31.92	.1828	37.08
83.00	32.11	.1828	37.67
84.00	32.29	.1828	38.27
85.00	32.73	.4570	39.02
86.00	32.95	.1828	39.78
87.00	33.35	.3656	40.02
88.00	33.73	.3656	40.27
89.00	34.11	.3656	40.41
90.00	34.50	.4570	40.41
91.00	35.03	.4570	40.41
92.00	35.[illegible]	-.[illegible]	40.41
93.00	35.33	-.[illegible]	40.41
94.00	35.33	-.[illegible]	40.41
95.00	35.33	-.[illegible]	40.41
96.00	35.33	-.[illegible]	40.41
97.00	35.33	-.[illegible]	40.41
98.00	35.33	-.[illegible]	40.41
99.00	35.33	-.0914	40.41
100.00	34.51	-.457	40.41

SITE DATA---

	X-ROTATED	Y-ROTATED		
	14.00	39.00	100	1
	53.00	27.00	100	1
	24.00	35.00	100	1
	53.00	42.00	100	1
	81.00	31.00	100	1
	76.00	44.00	100	1
	18.00	43.00	100	1
	58.00	44.00	100	1
	84.00	43.00	100	1
	52.00	25.00	100	1
	56.00	42.00	100	1
	59.00	49.00	100	1
	27.00	52.00	100	1
	15.00	49.00	100	1
	39.00	54.00	100	1
	57.00	18.00	100	1
	18.00	2.00	100	1
	71.00	54.00	100	1
	94.00	55.00	100	1
	57.00	51.00	100	1
	38.00	17.00	100	1
	56.00	15.00	100	1
	18.00	13.00	100	1
	36.00	26.00	100	1
	57.00	59.00	100	1
	47.00	14.00	100	1
	56.00	6.00	100	1
	55.00	22.00	100	1
	18.00	54.00	100	1
	83.00	59.00	100	1
	75.00	58.00	100	1
	96.00	49.00	100	1
	78.00	18.00	100	1
	94.00	32.00	100	1
	49.00	56.00	100	1
	50.00	2.00	100	1
	66.00	16.00	100	1
	89.00	16.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
1.00	34.51	-.4570	0.00
2.00	34.12	-.4570	0.00
3.00	33.52	-.4570	0.00
4.00	33.03	-.4570	0.00
5.00	32.54	-.4570	0.00
6.00	32.05	-.4570	0.00
7.00	31.55	-.4570	0.00
8.00	31.07	-.4570	.22
9.00	30.57	-.4570	.44
10.00	30.08	-.4570	.51
11.00	29.59	-.4570	.58
12.00	29.10	-.4570	.58
13.00	28.61	-.4570	.58
14.00	28.61	[illegible]	.58
15.00	28.61	[illegible]	.58
16.00	28.12	-.4570	.58
17.00	28.21	.0914	.99
18.00	28.31	.0914	1.41
19.00	28.73	.4570	2.69
20.00	28.73	[illegible]	3.46
21.00	28.73	[illegible]	4.22
22.00	28.73	[illegible]	4.98
23.00	28.93	.0914	5.74
24.00	29.37	.0914	6.50
25.00	29.47	.4570	8.14
26.00	29.55	.0914	9.58
27.00	29.55	.0914	9.80
28.00	30.14	.4570	10.02
29.00	30.23	.0914	10.23
30.00	30.52	.3656	10.45
31.00	31.00	.3656	10.52
32.00	31.13	.1828	10.66
33.00	31.37	.1828	10.79
34.00	31.55	.1828	10.79
35.00	31.64	.0914	10.79
36.00	31.74	.0914	10.79
37.00	31.83	.0914	10.79
38.00	31.92	.0914	10.79
39.00	32.01	.0914	10.79
40.00	32.10	.0914	10.79
41.00	32.18	.0914	10.79
42.00	32.29	.0914	10.79
43.00	32.38	.0914	10.79
44.00	32.47	.0914	10.79
45.00	32.55	.0914	11.21

46.00	32.34	.2742	11.43
47.00	32.33	.0914	11.65
48.00	33.03	.0914	12.42
49.00	33.03	-.0000	13.43
50.00	33.03	-.0000	14.38
51.00	33.03	-.0000	15.37
52.00	33.03	-.0000	15.35
53.00	33.03	-.0000	17.56
54.00	33.03	-.0000	18.06
55.00	33.03	-.0000	18.57
56.00	33.03	-.0000	19.07
57.00	33.03	-.0000	19.64
58.00	33.31	.2742	20.23
59.00	33.59	.2742	20.66
60.00	33.87	.2742	20.93
61.00	34.25	.3656	21.05
62.00	34.34	.0914	21.13
63.00	34.44	.0914	21.19
64.00	34.53	.0914	21.26
65.00	34.62	.0914	21.26
66.00	34.71	.0914	21.26
67.00	34.22	-.4570	21.26
68.00	33.73	-.4570	21.26
69.00	33.91	.1828	21.26
70.00	33.42	-.4570	21.26
71.00	33.91	.4570	21.26
72.00	33.63	-.2742	21.66
73.00	33.35	-.2742	22.09
74.00	33.07	-.2742	23.38
75.00	32.79	-.2742	24.66
76.00	32.51	-.2742	26.22
77.00	32.01	-.4570	27.78
78.00	31.83	-.1828	29.29
79.00	31.74	-.0914	30.81
80.00	31.65	-.0914	31.50
81.00	31.55	-.0000	32.19
82.00	31.33	.1828	33.15
83.00	32.21	.3656	33.74
84.00	32.50	.3656	34.34
85.00	33.03	.4570	35.32
86.00	33.37	.2742	35.78
87.00	33.65	.2742	36.09
88.00	33.93	.2742	36.30
89.00	34.21	.2742	36.44
90.00	34.7[illegible]	.4570	36.44
91.00	35.2[illegible]	.4570	36.44
92.00	35.21	-.0000	36.44
93.00	35.21	-.0000	36.44
94.00	35.21	-.0000	36.44
95.00	35.21	-.0000	36.44
96.00	35.21	-.0000	36.44
97.00	35.12	-.0914	36.44
98.00	35.12	-.0[illegible]	36.44
99.00	35.[illegible]1	-.0914	36.44
100.00	[illegible].92	-.457	36.44

Appendix C4

Automatic Model Output

(see Table 3, 4 KM Column)

OPTIMUM FLIGHT PATH INPUT SUMMARY---

```
CHECKPT 1--    [illegible],   35.000     A/C VELOCITY--MIN=648.0     CORRIDOR WIDTH= 2 .
        2-- 100.[illegible],   35.000                   MAX=722.0       AWARE RADIUS=1[illegible]

NRAYS=11     NO STEPS=25     NO SITES= 38     NO SITE TYPES=    1

NO. OF MEASUREMENTS=    1     SIGMA(RANGE)=     0.[illegible]     SIGMA(ANGLE)=     [illegible] DEG.
```

PK DATA--EACH SITE TYPE

SITE TYPE= 10[illegible]   SITE TYPE NO= 1

COLUMNS=RINGS,ROWS=SECTORS

.133	.125	.117	.079
.272	.217	.172	.1[illegible]7
.281	.235	.263	.136
.231	.137	.033	.044
.075	.140	.012	.025

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	[illegible]	100	1
70.00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	27.50	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
[illegible]	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
34.00	65.00	100	1
57.00	61.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1
90.00	49.00	100	1
76.00	18.00	100	1
34.00	62.00	100	1
45.00	54.00	100	1
50.00	2.00	100	1
66.00	16.00	100	1
39.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	35.00	-.0000	0.00
8.00	35.00	-.0000	5.13
12.00	35.00	-.0000	11.69
16.00	35.00	-.0000	20.02
20.00	35.00	-.0000	27.51
24.00	35.00	-.0000	30.29
28.00	35.00	-.0000	33.31
32.00	35.00	-.0000	33.87
36.00	35.00	-.0000	33.87
40.00	35.00	-.0000	33.87
44.00	34.63	-.0914	33.87
48.00	34.27	-.0914	35.64
52.00	34.63	.0914	42.62
56.00	35.00	.0914	45.51
60.00	34.26	-.1828	47.27
64.00	32.29	-.4570	50.58
68.00	31.93	-.0914	50.84
72.00	31.56	-.0914	52.51
76.00	31.56	-.0000	58.76
80.00	33.53	.4570	62.58
84.00	34.27	.1828	66.49
88.00	34.63	.0914	67.31
92.00	34.63	-.0000	67.31
96.00	34.63	-.0000	67.31
100.00	32.67	-.4570	67.31

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	30.00	100	1
70.00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	30.00	100	1
63.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
60.00	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
94.00	65.00	100	1
57.00	60.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
35.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	69.00	100	1
75.00	58.00	100	1
97.00	49.00	100	1
76.00	18.00	100	1
94.00	62.00	100	1
45.00	54.00	100	1
60.00	2.00	100	1
66.00	16.00	100	1
83.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	35.00	-.0000	.00
8.00	35.00	-.0000	5.13
12.00	35.00	-.0000	11.69
16.00	35.00	-.0000	20.02
20.00	35.00	-.0000	27.51
24.00	35.00	-.0000	30.29
28.00	35.00	-.0000	33.31
32.00	35.00	-.0000	33.87
36.00	34.63	-.0914	33.87
40.00	34.27	-.0914	33.87
44.00	33.90	-.0914	33.87
48.00	34.27	.0914	37.31
52.00	33.90	-.0914	47.49
56.00	33.53	-.0914	53.44
60.00	32.79	-.1828	60.38
64.00	30.83	-.4570	63.98
68.00	30.46	-.0914	64.24
72.00	30.83	.0914	65.91
76.00	31.19	.0914	72.16
80.00	29.23	-.4570	74.93
84.00	30.35	.2742	77.31
88.00	32.32	.4570	78.29
92.00	33.05	.1828	78.29
96.00	34.18	.2742	78.29
100.00	32.22	-.4570	78.29

SITE DATA---

X-ROTATED Y-ROTATED

14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	30.00	100	1
70.00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
55.00	32.50	100	1
59.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
60.00	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
94.00	65.00	100	1
57.00	60.00	100	1
39.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1
[illegible]	49.00	100	1
76.00	18.00	100	1
94.00	62.00	100	1
45.00	54.00	100	1
[illegible]	2.00	100	1
65.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	33.03	-.4570	0.00
8.00	33.03	-.0000	1.67
12.00	33.03	-.0000	4.71
16.00	33.03	-.0000	7.24
20.00	33.03	-.0000	14.04
24.00	33.03	-.0000	16.82
28.00	33.03	-.0000	19.84
32.00	33.03	-.0000	20.40
36.00	33.03	-.0000	20.40
40.00	33.40	.0914	20.40
44.00	33.40	-.0000	20.40
48.00	33.77	.0914	23.84
52.00	33.40	-.0914	34.02
56.00	33.77	.0914	37.76
60.00	33.03	-.1828	41.93
64.00	31.06	-.4570	45.53
68.00	31.06	-.0000	45.80
72.00	31.06	-.0000	47.47
76.00	31.06	-.0000	53.71
80.00	33.03	.4570	57.53
84.00	33.77	.1828	61.44
88.00	34.51	.1828	62.27
92.00	34.51	-.0000	62.27
96.00	34.87	.0914	62.27
100.00	32.91	-.4570	62.27

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	30.00	100	1
70.00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	35.00	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
60.00	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
94.00	65.00	100	1
57.00	60.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
19.00	64.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1
90.00	49.00	100	1
76.00	18.00	100	1
94.00	62.00	100	1
45.00	54.00	100	1
60.00	2.00	100	1
66.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	33.03	-.4570	0.00
8.00	33.03	-.0000	1.67
12.00	33.03	-.0000	4.71
16.00	33.03	-.0000	7.24
20.00	33.03	-.0000	14.04
24.00	33.03	-.0000	16.82
28.00	33.03	-.0000	19.84
32.00	33.03	-.0000	20.40
36.00	33.03	-.0000	20.40
40.00	33.40	.0914	20.40
44.00	33.77	.0914	20.40
48.00	34.13	.0914	23.84
52.00	33.77	-.0914	34.02
56.00	33.40	-.0914	37.76
60.00	33.03	-.0914	41.93
64.00	31.07	-.4570	45.53
68.00	31.07	-.0000	45.80
72.00	31.07	-.0000	47.47
76.00	31.07	-.0000	53.71
80.00	33.03	.4570	57.53
84.00	33.77	.1828	61.44
88.00	34.51	.1828	62.27
92.00	34.51	-.0000	62.27
96.00	34.89	.0914	62.27
100.00	32.91	-.4570	62.27

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	31.00	100	1
7[illegible].00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	37.50	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
5[illegible].00	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
94.00	65.00	100	1
57.00	60.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1
90.00	49.00	100	1
76.00	18.00	100	1
94.00	62.00	100	1
45.00	54.00	100	1
6[illegible].00	2.00	100	1
66.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	33.03	-.4570	0.00
8.00	33.03	-.0000	1.67
12.00	33.03	-.0000	4.71
16.00	33.03	-.0000	7.24
20.00	33.03	-.0000	14.04
24.00	33.03	-.0000	16.82
28.00	33.40	.0914	19.84
32.00	33.77	.0914	20.40
36.00	33.77	-.0000	20.40
40.00	33.77	-.0000	20.40
44.00	33.40	-.0914	20.40
48.00	33.03	-.0914	25.11
52.00	33.40	.0914	35.29
56.00	33.03	-.0914	42.20
60.00	33.40	.0914	49.42
64.00	31.43	-.4570	52.47
68.00	31.43	-.0000	52.73
72.00	31.43	-.0000	54.40
76.00	31.43	-.0000	60.64
80.00	33.40	.4570	64.47
84.00	34.14	.1828	68.38
88.00	34.51	.0914	69.20
92.00	34.51	-.0000	69.20
96.00	34.87	.0914	69.20
100.00	32.91	-.4570	69.20

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	100	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	35.00	100	1
70.00	44.00	100	1
18.00	43.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	45.00	100	1
69.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
60.00	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
94.00	65.00	100	1
57.00	60.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1
93.00	49.00	100	1
76.00	18.00	100	1
94.00	62.00	100	1
45.00	54.00	100	1
60.00	2.00	100	1
65.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	35.00	-.0000	0.00
8.00	35.00	-.0000	5.13
12.00	35.00	-.0000	11.69
16.00	35.00	-.0000	20.02
20.00	35.00	-.0000	27.51
24.00	34.63	-.0914	30.11
28.00	34.27	-.0914	33.13
32.00	33.90	-.0914	33.69
36.00	33.90	-.0000	33.69
40.00	33.90	-.0000	33.69
44.00	33.53	-.0914	33.69
48.00	33.17	-.0914	36.73
52.00	33.53	.0914	43.71
56.00	33.17	-.0914	45.71
60.00	32.80	-.0914	47.42
64.00	30.83	-.4570	50.47
68.00	30.47	-.0914	50.73
72.00	30.83	.0914	52.40
76.00	31.20	.0914	58.64
80.00	29.23	-.4570	61.42
84.00	30.36	.2742	63.80
88.00	32.33	.4570	64.78
92.00	33.06	.1828	64.78
96.00	34.19	.2742	64.78
100.00	32.22	-.4570	64.78

SITE DATA---

X-ROTATED	Y-ROTATED		
14.00	39.00	100	1
53.00	27.00	1[illegible]	1
24.00	35.00	100	1
53.00	42.00	100	1
81.00	30.00	100	1
7[illegible].00	44.00	100	1
18.00	47.00	100	1
56.00	44.00	100	1
84.00	43.00	100	1
62.00	25.00	100	1
56.00	42.50	100	1
68.00	49.00	100	1
27.00	52.00	100	1
15.00	49.00	100	1
39.00	64.00	100	1
60.00	18.00	100	1
18.00	2.00	100	1
71.00	64.00	100	1
94.00	65.00	100	1
57.00	60.00	100	1
38.00	17.00	100	1
56.00	15.00	100	1
18.00	13.00	100	1
36.00	20.00	100	1
67.00	59.00	100	1
47.00	14.00	100	1
60.00	6.00	100	1
55.00	22.00	100	1
18.00	64.00	100	1
83.00	69.00	100	1
76.00	58.00	100	1
90.00	49.00	100	1
76.00	18.00	100	1
94.00	62.00	100	1
45.00	54.00	100	1
5[illegible].00	2.00	100	1
66.00	16.00	100	1
89.00	18.00	100	1

PROGRAM OUTPUT---

X-ROTATED	Y-ROTATED	ANG(RAD)	EXPOSURE
4.00	35.00	-.0000	0.00
8.00	35.00	-.0000	5.13
12.00	35.00	-.0000	11.69
16.00	35.00	-.0000	20.02
20.00	35.00	-.0000	27.51
24.00	35.00	-.0000	3[illegible].29
28.00	35.00	-.0000	33.31
32.00	34.63	-.0914	33.87
36.00	34.27	-.0914	33.87
40.00	33.90	-.0914	33.87
44.00	33.53	-.0914	33.87
48.00	33.53	-.0000	35.64
52.00	33.90	.0914	40.47
56.00	33.53	-.0914	41.87
60.00	32.79	-.1828	43.02
64.00	30.83	-.4570	46.07
68.00	30.46	-.0914	46.33
72.00	30.83	.0914	48.00
76.00	31.19	.0914	54.24
80.00	29.23	-.4570	57.02
84.00	30.35	.2742	59.40
88.00	32.32	.4570	60.38
92.00	33.[illegible]5	.1828	60.38
96.00	34.18	.2742	60.38
100.00	32.22	-.4570	60.38

Appendix C5

Uncertain Model Output

(see Table 5)

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	42.33
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	39.21
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	39.34
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	39.96
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	47.72
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

1[illegible].[illegible]	3[illegible].33	-.[illegible]	[illegible].33
1[illegible].[illegible]	3[illegible].23	-.[illegible]	[illegible].7[illegible]
1[illegible].[illegible]	3[illegible].29	-.[illegible]	[illegible].[illegible]7
1[illegible].[illegible]	3[illegible].25	-.[illegible]	[illegible].19
1[illegible].[illegible]	3[illegible].4[illegible]	-.[illegible]57[illegible]	[illegible].[illegible]9
1[illegible].[illegible]	3[illegible].22	-.[illegible]	[illegible].52
1[illegible].[illegible]	3[illegible].34	-.[illegible]	52.[illegible]
1[illegible].[illegible]	3[illegible].22	-.[illegible]	[illegible].93
1[illegible].[illegible]	3[illegible].43	-.[illegible]57	[illegible]3.[illegible]
1[illegible].[illegible]	3[illegible].[illegible]2	-.[illegible]	[illegible].[illegible]
1[illegible].[illegible]	3[illegible].31	-.[illegible]	[illegible].1
1[illegible].[illegible]	3[illegible].13	-.[illegible]	[illegible].[illegible]
1[illegible].[illegible]	3[illegible].[illegible]3	-.[illegible]	[illegible].9
1[illegible].[illegible]	3[illegible].[illegible]7	-.[illegible]	51.96
1[illegible].[illegible]	3[illegible].[illegible]1	-.[illegible]	[illegible].7[illegible]
1[illegible].[illegible]	3[illegible].23	-.[illegible]	[illegible]1.23
1[illegible].[illegible]	3[illegible].2[illegible]	-.[illegible]	[illegible].[illegible]3
1[illegible].[illegible]	3[illegible].25	-.[illegible]57	47.59
1[illegible].[illegible]	3[illegible].[illegible]1	-.[illegible]57	6[illegible].63
1[illegible].[illegible]	3[illegible].71	-.[illegible]	52.[illegible]7
1[illegible].[illegible]	3[illegible].23	-.[illegible]57	49.33
1[illegible].[illegible]	3[illegible].27	-.[illegible]57	5[illegible].11
1[illegible].[illegible]	3[illegible].23	-.[illegible]57	4[illegible].[illegible]7
1[illegible].[illegible]	3[illegible].31	-.[illegible]	40.73
1[illegible].[illegible]	3[illegible].33	-.[illegible]57	53.98
1[illegible].[illegible]	3[illegible].29	-.[illegible]57	48.48
1[illegible].[illegible]	3[illegible].29	-.[illegible]57	52.35
1[illegible].[illegible]	3[illegible].39	-.[illegible]57	51.62
1[illegible].[illegible]	3[illegible].32	-.[illegible]57[illegible]	57.[illegible]1
1[illegible].[illegible]	3[illegible].23	-.[illegible]57[illegible]	49.38
1[illegible].[illegible]	35.25	-.[illegible]57[illegible]	56.24
1[illegible].[illegible]	3[illegible].27	-.[illegible]57	45.59
1[illegible].[illegible]	3[illegible].33	-.[illegible]57[illegible]	5[illegible].5[illegible]
1[illegible].[illegible]	3[illegible].19	-.[illegible]57	51.72
1[illegible].[illegible]	3[illegible].73	-.[illegible]57[illegible]	56.38
1[illegible].[illegible]	3[illegible].[illegible]3	-.[illegible]	54.55
1[illegible].[illegible]	3[illegible].72	-.[illegible]57[illegible]	5[illegible].[illegible]7
1[illegible].[illegible]	3[illegible].29	-.[illegible]57	45.19
1[illegible].[illegible]	3[illegible].[illegible]	-.[illegible]57[illegible]	[illegible]5.74
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1[illegible].[illegible]	[illegible]	-.[illegible]7	4[illegible].77
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1[illegible]	3[illegible].27	-.[illegible]	32.6[illegible]
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1[illegible]	3[illegible].70	-.[illegible]	3[illegible].15
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1[illegible]	3[illegible].27	-.[illegible]7	3[illegible].[illegible]9
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1[illegible]	3[illegible].72	-.[illegible]7	3[illegible].68
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1[illegible]	3[illegible].15	-.[illegible]	33.[illegible]
1[illegible]	3[illegible].75	-.[illegible]	37.59
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1[illegible]	3[illegible].73	-.[illegible]7	41.[illegible]2
1[illegible]	3[illegible].24	-.[illegible]7	3[illegible].23
1[illegible]	3[illegible].25	-.[illegible]7	41.85
1[illegible]	3[illegible].24	-.[illegible]	3[illegible].32
1[illegible]	3[illegible].24	-.[illegible]7	4[illegible].93
1[illegible]	3[illegible].71	-.[illegible]	41.71
1[illegible]	3[illegible].73	-.[illegible]	42.53
1[illegible]	3[illegible].[illegible]	-.[illegible]	[illegible]1.[illegible]
1[illegible]	3[illegible].27	-.[illegible]	37.39
1[illegible]	3[illegible].[illegible]	-.[illegible]	33.1[illegible]
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1[illegible]	3[illegible].[illegible]	-.[illegible]	[illegible]3.82

Appendix C6

Manual Model Output

(see Table 6)

1[illegible]	37.17	-.[illegible]	3[illegible].49
1[illegible]	37.14	-.457	33.86
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1[illegible]	37.13	-.[illegible]	[illegible].29
1[illegible]	37.23	-.457	33.83
1[illegible]	37.35	-.[illegible]	28.93
1[illegible]	37.13	-.[illegible]	3[illegible].13
1[illegible]	37.[illegible]4	-.[illegible]	3[illegible].3[illegible]
1[illegible]	37.[illegible]5	-.457	2[illegible].15
1[illegible]	37.21	-.[illegible]7	32.09
1[illegible]	37.23	-.[illegible]	32.99
1[illegible]	37.33	-.[illegible]7	42.79
1[illegible]	37.23	-.[illegible]7	33.[illegible]
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1[illegible]	37.25	-.[illegible]	3[illegible].32
1[illegible]	37.35	-.[illegible]7	27.6[illegible]
1[illegible]	37.23	-.[illegible]7	4[illegible].[illegible]8
1[illegible]	37.21	-.[illegible]57	3[illegible].01
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1[illegible]	37.23	-.[illegible]7	32.[illegible]3
1[illegible]	37.13	-.[illegible]	4[illegible].8[illegible]
1[illegible]	37.17	-.457	3[illegible].49
1[illegible]	37.14	-.457	37.98
1[illegible]	33.75	-.457	3[illegible].43
1[illegible]	37.17	-.[illegible]57	31.52
1[illegible]	37.13	-.[illegible]	33.18
1[illegible]	37.21	-.[illegible]57	34.85
1[illegible]	37.24	-.[illegible]	31.64
1[illegible]	37.27	-.457	4[illegible].[illegible]5
1[illegible]	37.27	-.[illegible]7	31.37
1[illegible]	33.17	-.457	43.72
1[illegible]	37.25	-.457	28.94
1[illegible]	37.15	-.[illegible]7	3[illegible].85
1[illegible]	37.25	-.[illegible]57	3[illegible].[illegible]
1[illegible]	37.32	-.457	34.12
1[illegible]	37.17	-.[illegible]57	31.[illegible]
1[illegible]	37.[illegible]4	-.[illegible]7	3[illegible].91
1[illegible]	37.[illegible]5	-.[illegible]7	30.76
1[illegible]	37.15	-.457	37.22

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10.3[illegible]	33.15	-.457[illegible]	45.56
10.[illegible]	33.33	-.[illegible]57[illegible]	47.87
10.[illegible]	33.12	-.[illegible]57[illegible]	47.4[illegible]
10.[illegible]	33.17	-.[illegible]57[illegible]	51.37
10.[illegible]	33.34	-.457[illegible]	48.34
10.[illegible]	33.21	-.[illegible]7[illegible]	45.93
10.[illegible]	33.35	-.[illegible]57[illegible]	4[illegible].[illegible]7
10.[illegible]	33.34	-.[illegible]57[illegible]	47.52
10.[illegible]	33.[illegible]3	-.[illegible]	43.[illegible]
10.[illegible]	33.37	-.[illegible]57	4[illegible].[illegible]
10.[illegible]	33.19	-.[illegible]57	4[illegible].78
10.[illegible]	33.33	-.[illegible]57	5[illegible].9[illegible]
10.[illegible]	33.25	-.[illegible]5[illegible]	49.46
10.[illegible]	33.27	-.457[illegible]	45.86
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10.[illegible]	33.13	-.[illegible]57[illegible]	[illegible]2.73
10.[illegible]	33.23	-.[illegible]5[illegible]	[illegible].83
10.[illegible]	33.31	-.457[illegible]	48.27
10.[illegible]	33.44	-.[illegible]7[illegible]	5[illegible].94
10.[illegible]	33.25	-.[illegible]57	3[illegible].97
10.[illegible]	33.53	-.[illegible]57	45.[illegible]6
10.[illegible]	33.35	-.[illegible]57[illegible]	45.[illegible]6
10.[illegible]	33.13	-.457[illegible]	51.17
10.3[illegible]	33.33	-.[illegible]57[illegible]	53.21
10.[illegible]	33.24	-.[illegible]57	49.68
10.[illegible]	33.15	-.[illegible]5[illegible]	49.1[illegible]
10.[illegible]	33.27	-.[illegible]57[illegible]	51.47
10.[illegible]	33.33	-.[illegible]7[illegible]	47.[illegible]
10.[illegible]	33.3[illegible]	-.[illegible]57[illegible]	5[illegible].15
10.[illegible]	33.14	-.[illegible]5[illegible]	45.73
10.[illegible]	33.25	-.[illegible]57[illegible]	55.83
10.[illegible]	33.23	-.[illegible]57[illegible]	38.27
10.[illegible]	33.32	-.[illegible]57[illegible]	45.62
10.[illegible]	33.13	-.[illegible]57[illegible]	45.19
10.[illegible]	33.23	-.457[illegible]	4[illegible].59
10.[illegible]	33.3[illegible]	-.[illegible]57	3[illegible].82
10.[illegible]	33.[illegible]3	-.[illegible]57[illegible]	5[illegible].[illegible]3
10.[illegible]	33.33	-.[illegible]57[illegible]	4[illegible].37
10.[illegible]	33.[illegible]7	-.457[illegible]	47.13

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[illegible]	37.34	[illegible]	42.39
[illegible]	[illegible]	[illegible]	42.27
[illegible]	37.32	[illegible]	[illegible]
[illegible]	33.32	[illegible]	[illegible]
[illegible]	33.17	[illegible]	[illegible]
[illegible]	37.34	[illegible]	[illegible]
[illegible]	37.17	[illegible]	[illegible]
[illegible]	37.35	[illegible]	47.38
[illegible]	33.35	[illegible]	[illegible]
[illegible]	33.27	[illegible]	42.45
[illegible]	33.33	[illegible]	[illegible]
[illegible]	37.23	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	37.27	-.457	47.3
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	37.35	[illegible]	[illegible]
[illegible]	37.33	[illegible]	43.27
[illegible]	33.25	[illegible]	[illegible]
[illegible]	33.13	[illegible]	[illegible]
[illegible]	33.35	[illegible]	[illegible]
[illegible]	37.23	[illegible]	[illegible]
[illegible]	33.13	[illegible]	45.35
[illegible]	[illegible]	[illegible]	45.92
[illegible]	37.23	[illegible]	41.64
[illegible]	33.23	[illegible]	52.39
[illegible]	33.24	-.4577	46.68
[illegible]	37.31	[illegible]	[illegible]
[illegible]	33.23	[illegible]	[illegible]
[illegible]	37.23	[illegible]	[illegible]
[illegible]	37.13	[illegible]	[illegible]
[illegible]	37.35	[illegible]	[illegible]
[illegible]	33.25	[illegible]	41.16
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	33.33	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	43.61

[illegible]	37.35	-.[illegible]	[illegible]2.92
[illegible]	37.13	-.4[illegible]	41.27
[illegible]	37.34	-.[illegible]	[illegible].7[illegible]
[illegible]	37.22	-.[illegible]	[illegible]
[illegible]	37.32	-.[illegible]	[illegible].99
[illegible]	37.23	-.457	42.79
[illegible]	37.13	-.[illegible]57	49.[illegible]
[illegible]	37.35	-.[illegible]	[illegible].1[illegible]
[illegible]	37.[illegible]	-.[illegible]	47.[illegible]2
[illegible]	37.[illegible]3	-.[illegible]	3[illegible].11
[illegible]	37.2[illegible]	-.[illegible]	43.[illegible]
[illegible]	37.1[illegible]	-.[illegible]	43.[illegible]
[illegible]	37.[illegible]5	-.[illegible]	[illegible].33
[illegible]	37.35	-.[illegible]	42.8[illegible]
[illegible]	37.25	-.4[illegible]7	41.42
[illegible]	37.32	-.[illegible]	[illegible].[illegible]3
[illegible]	37.13	-.[illegible]	41.[illegible]7
[illegible]	37.23	-.[illegible]57	[illegible].24
[illegible]	37.31	-.457	4[illegible].26
[illegible]	37.1[illegible]	-.[illegible]57	[illegible].63
[illegible]	37.23	-.[illegible]	43.78
[illegible]	37.2[illegible]	-.[illegible]	49.9[illegible]
[illegible]	37.25	-.[illegible]	42.61
[illegible]	37.1[illegible]	-.457	4[illegible].83
[illegible]	37.35	-.[illegible]	49.63
[illegible]	37.23	-.457	45.[illegible]2
[illegible]	37.14	-.[illegible]	48.[illegible]3
[illegible]	37.2[illegible]	-.457	45.16
[illegible]	37.32	-.[illegible]57	41.7[illegible]
[illegible]	37.15	-.[illegible]57	5[illegible].17
[illegible]	37.14	-.457	42.61
[illegible]	37.31	-.457	52.[illegible]2
[illegible]	37.[illegible]8	-.[illegible]57	37.3[illegible]
[illegible]	37.3[illegible]	-.[illegible]	4[illegible].17
[illegible]	37.13	-.[illegible]	41.9[illegible]
[illegible]	37.35	-.457	[illegible].7
[illegible]	37.34	-.[illegible]	[illegible]
[illegible]	37.[illegible]2	-.[illegible]	[illegible]1
[illegible]	[illegible].[illegible]3	-.[illegible]	[illegible]
[illegible]	[illegible]	-.[illegible]	[illegible]

10[illegible]	33.21	-.457[illegible]	43.29
10[illegible]	33.17	-.457[illegible]	5[illegible].32
10[illegible]	33.33	-.4[illegible]	4[illegible].7[illegible]
10[illegible]	33.33	-.457	5[illegible].96
10[illegible]	33.13	-.457	52.53
10[illegible]	33.23	-.457[illegible]	45.94
10[illegible]	33.[illegible]	-.457	46.[illegible]2
10[illegible]	33.[illegible]	-.457[illegible]	49.27
10[illegible]	33.[illegible]	-.[illegible]57	5[illegible].[illegible]2
10[illegible]	33.1[illegible]	-.457[illegible]	39.1
10[illegible]	33.23	-.457[illegible]	4[illegible].2[illegible]
10[illegible]	33.23	-.457	45.6
10[illegible]	33.22	-.457[illegible]	52.9[illegible]
10[illegible]	33.31	-.457[illegible]	49.[illegible]
10[illegible]	33.24	-.457[illegible]	[illegible]7.72
10[illegible]	33.2[illegible]	-.457[illegible]	43.26
10[illegible]	33.24	-.457[illegible]	4[illegible].91
10[illegible]	33.24	-.457	5[illegible].39
10[illegible]	33.22	-.457[illegible]	49.[illegible]
10[illegible]	33.1[illegible]	-.457[illegible]	5[illegible].76
10[illegible]	33.1[illegible]	-.457[illegible]	4[illegible].39
10[illegible]	33.21	-.457[illegible]	5[illegible].[illegible]6
10[illegible]	33.13	-.457[illegible]	51.47
10[illegible]	33.23	-.457[illegible]	[illegible]7.26
10[illegible]	33.2[illegible]	-.457[illegible]	45.99
10[illegible]	33.24	-.457[illegible]	45.17
10[illegible]	33.13	-.457[illegible]	45.44
10[illegible]	33.22	-.457[illegible]	47.61
10[illegible]	33.25	-.457[illegible]	47.69
10[illegible]	33.23	-.457[illegible]	52.35
10[illegible]	33.25	-.457[illegible]	45.86
10[illegible]	33.25	-.457[illegible]	51.64
10[illegible]	33.24	-.457[illegible]	46.33
10[illegible]	33.15	-.457[illegible]	48.49
10[illegible]	33.34	-.457	49.17
10[illegible]	33.35	-.457[illegible]	47.39
10[illegible]	33.19	-.457[illegible]	43.97
10[illegible]	33.[illegible]1	-.457[illegible]	43.87
10[illegible]	3[illegible].1[illegible]	-.457[illegible]	46.62
10[illegible]	33.1[illegible]	-.457[illegible]	[illegible].91

[illegible]	33.34	-.457[illegible]	35.77
[illegible]	33.37	-.457[illegible]	[illegible]
[illegible]	33.24	-.457[illegible]	4[illegible].69
[illegible]	33.27	-.457[illegible]	41.2[illegible]
[illegible]	33.32	-.457[illegible]	4[illegible].79
[illegible]	33.12	-.457[illegible]	34.14
[illegible]	33.[illegible]	-.457[illegible]	39.61
[illegible]	33.[illegible]	-.457[illegible]	36.91
[illegible]	33.59	-.457[illegible]	4[illegible].8
[illegible]	33.13	-.457[illegible]	37.45
[illegible]	33.22	-.457[illegible]	36.[illegible]6
[illegible]	33.25	-.457[illegible]	36.45
[illegible]	32.97	-.457[illegible]	47.11
[illegible]	33.23	-.457[illegible]	35.[illegible]6
[illegible]	33.27	-.457[illegible]	35.[illegible]2
[illegible]	33.25	-.457[illegible]	3[illegible]
[illegible]	33.2[illegible]	-.457[illegible]	3[illegible].9[illegible]
[illegible]	33.24	-.457[illegible]	45.82
[illegible]	33.17	-.457[illegible]	36.94
[illegible]	33.13	-.457[illegible]	42.19
[illegible]	33.2[illegible]	-.457[illegible]	35.67
[illegible]	33.23	-.457[illegible]	4[illegible].71
[illegible]	33.15	-.457[illegible]	42.24
[illegible]	33.2[illegible]	-.457[illegible]	37.24
[illegible]	33.25	-.457[illegible]	4[illegible].97
[illegible]	33.2[illegible]	-.457[illegible]	34.78
[illegible]	33.14	-.457[illegible]	41.44
[illegible]	33.22	-.457[illegible]	4[illegible].83
[illegible]	33.23	-.457[illegible]	36.57
[illegible]	33.21	-.457[illegible]	46.68
[illegible]	33.31	-.457[illegible]	37.78
[illegible]	33.27	-.457[illegible]	4[illegible].59
[illegible]	33.14	-.457[illegible]	33.3[illegible]
[illegible]	33.32	-.457[illegible]	4[illegible].31
[illegible]	33.33	-.457[illegible]	39.37
[illegible]	33.34	-.457[illegible]	[illegible]
[illegible]	33.33	-.457[illegible]	35.43
[illegible]	33.[illegible]	-.457[illegible]	36.72
[illegible]	33.25	[illegible]	39.58
[illegible]	33.13	-.457[illegible]	4[illegible].22

10[illegible]	33.15	-.457	24.94
10[illegible]	33.37	-.457	25.98
10[illegible]	33.17	-.457	29.1[illegible]
10[illegible]	33.23	-.457	31.3[illegible]
10[illegible]	33.14	-.457	35.43
10[illegible]	33.27	-.4[illegible]	25.55
10[illegible]	33.27	-.457	3[illegible].4[illegible]
10[illegible]	33.25	-.457	31.6[illegible]
10[illegible]	33.24	-.457	33.[illegible]2
10[illegible]	33.[illegible]3	-.457	23.26
10[illegible].35	33.23	-.457	28.66
10[illegible]	33.25	-.457	28.66
10[illegible]	32.33	-.457	35.33
10[illegible]	33.23	-.457	3[illegible].26
10[illegible]	33.23	-.457	3[illegible].[illegible]
10[illegible]	33.25	-.457	27.42
10[illegible]	33.13	-.457	27.9[illegible]
10[illegible]	33.22	-.457	35.17
10[illegible]	33.13	-.457	31.39
10[illegible]	33.14	-.457	34.63
10[illegible]	33.15	-.457	27.61
10[illegible]	33.23	-.457	35.[illegible]8
10[illegible]	33.13	-.457	27.78
10[illegible].30	33.23	-.457	29.65
10[illegible]	33.25	-.457	31.25
10[illegible]	33.23	-.457	3[illegible].[illegible]2
10[illegible]	33.15	-.457	33.[illegible]9
10[illegible]	33.22	-.457	31.33
10[illegible]	33.25	-.457	28.[illegible]7
10[illegible]	33.15	-.457	36.79
10[illegible]	33.27	-.457	28.64
10[illegible]	33.27	-.457	35.74
10[illegible]	33.11	-.457	23.44
10[illegible]	33.22	-.457	31.17
10[illegible]	33.25	-.457	31.83
10[illegible]	33.35	-.457	29.17
10[illegible]	33.15	-.457	24.94
10[illegible]	33.4[illegible]	-.4[illegible]	32.[illegible]
10[illegible]	34.13	-.457	31.[illegible]2
10[illegible]	33.13	-.457	34.[illegible]4

Appendix C7

Data for Points on Figure 13

100.00	33.31	-.4570	47.36
100.00	33.32	-.4570	46.36
100.00	33.14	-.4570	58.84
100.00	33.35	-.4570	52.33
100.00	33.32	-.4570	49.46
100.00	33.37	-.4570	53.19
100.00	33.31	-.4570	49.15
100.00	33.17	-.4570	50.29
100.00	33.54	-.4570	49.94
100.00	33.23	-.4570	45.34
100.00	33.53	-.4570	39.71
100.00	33.24	-.4570	43.44
100.00	33.51	-.4570	46.67
100.00	33.13	-.4570	45.11
100.00	33.40	-.4570	42.31
100.00	33.39	-.4570	46.77
100.00	33.55	-.4570	48.69
100.00	33.54	-.4570	43.07
100.00	33.04	-.4570	44.24
100.00	33.30	-.4570	44.00
100.00	33.32	-.4570	46.48
100.00	33.20	-.4570	42.05
100.00	33.35	-.4570	44.52
100.00	33.15	-.4570	42.15
100.00	32.95	-.4570	48.70
100.00	33.45	-.4570	43.83
100.00	33.50	-.4570	45.31
100.00	33.15	-.4570	42.30
100.00	33.25	-.4570	43.23
100.00	33.31	-.4570	45.32
100.00	33.49	-.4570	53.80
100.00	33.37	-.4570	45.28
100.00	33.21	-.4570	43.89
100.00	33.23	-.4570	51.54
100.00	33.35	-.4570	47.10
100.00	32.35	-.4570	44.44
100.00	33.37	-.4570	45.48
100.00	33.32	-.4570	45.23
100.00	33.41	-.4570	45.39
100.00	33.31	-.4570	45.29

100.00	33.31	-.4570	48.87
100.00	33.34	-.4570	45.34
100.00	33.37	-.4570	60.85
100.00	33.73	-.4570	52.78
100.00	33.31	-.4570	51.17
100.00	33.35	-.4570	50.79
100.00	33.31	-.4570	49.44
100.00	33.15	-.4570	48.87
100.00	33.87	-.4570	51.33
100.00	33.25	-.4570	44.91
100.00	33.43	-.4570	41.31
100.00	33.13	-.4570	42.18
100.00	33.79	-.4570	48.87
100.00	33.34	-.4570	48.94
100.00	33.41	-.4570	42.61
100.00	33.38	-.4570	47.07
100.00	33.45	-.4570	48.81
100.00	33.53	-.4570	44.88
100.00	33.32	-.4570	48.76
100.00	33.25	-.4570	45.86
100.00	33.32	-.4570	46.16
100.00	33.20	-.4570	46.81
100.00	33.43	-.4570	44.38
100.00	33.17	-.4570	43.16
100.00	33.31	-.4570	49.27
100.00	33.43	-.4570	47.35
100.00	33.75	-.4570	45.56
100.00	33.15	-.4570	41.08
100.00	33.15	-.4570	43.41
100.00	33.31	-.4570	44.10
100.00	33.44	-.4570	53.50
100.00	33.13	-.4570	45.15
100.00	33.28	-.4570	43.02
100.00	33.22	-.4570	54.61
100.00	33.72	-.4570	53.40
100.00	32.94	-.4570	44.27
100.00	33.35	-.4570	44.38
100.00	33.35	-.4570	44.03
100.00	33.41	-.4570	45.68
100.00	33.20	-.4570	46.90

100.00	33.27	-.4570	53.72
100.00	33.19	-.4570	44.83
100.00	33.11	-.4570	55.87
100.00	33.74	-.4570	57.78
100.00	33.22	-.4570	54.58
100.00	33.35	-.4570	55.28
100.00	33.25	-.4570	43.30
100.00	33.21	-.4570	54.98
100.00	33.57	-.4570	51.67
100.00	33.23	-.4570	47.84
100.00	33.51	-.4570	40.86
100.00	33.14	-.4570	47.64
100.00	33.31	-.4570	47.93
100.00	33.23	-.4570	51.40
100.00	33.41	-.4570	49.46
100.00	33.23	-.4570	51.54
100.00	33.41	-.4570	52.47
100.00	33.25	-.4570	48.27
100.00	33.34	-.4570	48.98
100.00	33.21	-.4570	47.65
100.00	33.25	-.4570	41.11
100.00	33.22	-.4570	47.98
100.00	33.43	-.4570	48.52
100.00	33.37	-.4570	46.54
100.00	32.95	-.4570	52.92
100.00	33.44	-.4570	45.48
100.00	33.52	-.4570	48.56
100.00	33.21	-.4570	48.92
100.00	33.17	-.4570	46.56
100.00	33.23	-.4570	50.80
100.00	33.44	-.4570	54.01
100.00	32.93	-.4570	45.29
100.00	33.29	-.4570	45.73
100.00	33.25	-.4570	47.58
100.00	33.82	-.4570	53.56
100.00	32.35	-.4570	44.69
100.00	33.37	-.4570	48.01
100.00	33.35	-.4570	50.49
100.00	33.43	-.4570	50.03
100.00	33.21	-.4570	47.65

100.00	33.34	-.4570	52.22
100.00	33.34	-.4570	54.81
100.00	33.35	-.4570	60.86
100.00	33.73	-.4570	52.39
100.00	33.31	-.4570	53.56
100.00	33.27	-.4570	54.43
100.00	33.31	-.4570	51.71
100.00	33.17	-.4570	52.64
100.00	33.32	-.4570	61.67
100.00	33.23	-.4570	47.10
100.00	33.32	-.4570	51.02
100.00	33.27	-.4570	48.43
100.00	33.32	-.4570	52.72
100.00	33.33	-.4570	49.12
100.00	33.53	-.4570	47.48
100.00	33.31	-.4570	50.11
100.00	33.47	-.4570	52.87
100.00	33.35	-.4570	48.24
100.00	33.34	-.4570	50.82
100.00	33.25	-.4570	51.90
100.00	33.17	-.4570	51.60
100.00	33.23	-.4570	47.47
100.00	33.42	-.4570	44.32
100.00	33.11	-.4570	45.57
100.00	33.23	-.4570	50.35
100.00	33.34	-.4570	55.94
100.00	33.73	-.4570	46.47
100.00	33.15	-.4570	50.99
100.00	33.32	-.4570	45.52
100.00	33.33	-.4570	46.50
100.00	33.33	-.4570	57.52
100.00	33.27	-.4570	50.25
100.00	33.13	-.4570	42.44
100.00	33.25	-.4570	54.52
100.00	33.57	-.4570	56.94
100.00	33.15	-.4570	48.56
100.00	33.24	-.4570	49.69
100.00	33.35	-.4570	52.81
100.00	33.33	-.4570	49.51
100.00	33.23	-.4570	48.53

100.00	33.22	-.4570	41.14
100.00	33.25	-.4570	39.81
100.00	33.33	-.4570	49.95
100.00	33.73	-.4570	46.99
100.00	33.24	-.4570	38.12
100.00	33.20	-.4570	46.08
100.00	33.23	-.4570	38.69
100.00	33.35	-.4570	44.74
100.00	33.33	-.4570	54.88
100.00	33.22	-.4570	42.11
100.00	33.47	-.4570	31.50
100.00	33.23	-.4570	38.55
100.00	33.30	-.4570	47.28
100.00	33.35	-.4570	39.89
100.00	33.42	-.4570	38.47
100.00	33.23	-.4570	40.83
100.00	33.45	-.4570	44.91
100.00	33.13	-.4570	44.68
100.00	33.34	-.4570	44.49
100.00	33.17	-.4570	40.83
100.00	33.17	-.4570	37.11
100.00	33.15	-.4570	40.82
100.00	33.37	-.4570	40.80
100.00	33.11	-.4570	36.68
100.00	33.25	-.4570	45.00
100.00	33.33	-.4570	43.83
100.00	33.75	-.4570	43.29
100.00	33.15	-.4570	37.42
100.00	33.37	-.4570	30.69
100.00	33.20	-.4570	35.97
100.00	33.41	-.4570	47.15
100.00	33.37	-.4570	36.59
100.00	33.23	-.4570	37.58
100.00	33.27	-.4570	44.75
100.00	33.53	-.4570	49.18
100.00	33.13	-.4570	38.97
100.00	33.25	-.4570	36.47
100.00	33.23	-.4570	44.18
100.00	33.33	-.4570	39.41
100.00	33.74	-.4570	36.14

100.00	33.24	-.4570	36.34
100.00	33.27	-.4570	37.33
100.00	32.97	-.4570	44.61
100.00	33.79	-.4570	39.51
100.00	33.30	-.4570	34.83
100.00	33.27	-.4570	37.22
100.00	33.27	-.4570	33.81
100.00	33.33	-.4570	35.20
100.00	33.32	-.4570	37.82
100.00	33.19	-.4570	31.39
100.00	33.47	-.4570	24.80
100.00	33.13	-.4570	32.44
100.00	33.83	-.4570	31.54
100.00	33.34	-.4570	35.26
100.00	33.59	-.4570	28.94
100.00	33.27	-.4570	33.84
100.00	33.45	-.4570	40.28
100.00	33.35	-.4570	32.53
100.00	33.34	-.4570	37.16
100.00	33.19	-.4570	32.39
100.00	33.15	-.4570	31.90
100.00	33.15	-.4570	36.42
100.00	33.42	-.4570	29.20
100.00	33.34	-.4570	30.94
100.00	33.45	-.4570	38.97
100.00	33.31	-.4570	29.46
100.00	33.75	-.4570	27.58
100.00	33.14	-.4570	30.94
100.00	33.32	-.4570	26.81
100.00	33.20	-.4570	30.62
100.00	33.33	-.4570	39.85
100.00	33.37	-.4570	29.12
100.00	33.23	-.4570	29.65
100.00	33.25	-.4570	35.90
100.00	33.70	-.4570	38.86
100.00	32.85	-.4570	29.20
100.00	33.22	-.4570	30.52
100.00	33.35	-.4570	28.77
100.00	33.27	-.4570	32.75
100.00	33.41	-.4570	33.73

AD-A101 136 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOO--ETC F/G 1/3
QUANTIFYING REACTIVE MANEUVERS.(U)
MAR 81 J J ALT
UNCLASSIFIED AFIT/GST/OS/81M-1 NL

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CONT.

100.00	33.32	-.4570	27.10
100.00	33.95	-.4570	27.64
100.00	32.45	-.4570	33.02
100.00	33.17	-.4570	39.31
100.00	32.45	-.4570	33.83
100.00	33.25	-.4570	33.65
100.00	33.55	-.4570	28.27
100.00	32.53	-.4570	34.66
100.00	33.11	-.4570	39.31
100.00	33.51	-.4570	29.13
100.00	32.57	-.4570	35.36
100.00	32.29	-.4570	34.35
100.00	33.59	-.4570	28.27
100.00	33.59	-.4570	28.17
100.00	32.43	-.4570	34.11
100.00	32.35	-.4570	35.36
100.00	33.33	-.4570	26.41
100.00	32.57	-.4570	33.15
100.00	32.32	-.4570	35.83
100.00	33.53	-.4570	29.23
100.00	32.34	-.4570	34.68
100.00	33.34	-.4570	38.87
100.00	33.53	-.4570	35.26
100.00	33.49	-.4570	29.33
100.00	33.44	-.4570	37.84
100.00	33.12	-.4570	34.09
100.00	33.53	-.4570	29.09
100.00	33.59	-.4570	27.74
100.00	32.44	-.4570	33.57
100.00	33.47	-.4570	33.39
100.00	32.43	-.4570	33.63
100.00	33.37	-.4570	32.96
100.00	32.51	-.4570	38.83
100.00	33.51	-.4570	27.66
100.00	32.45	-.4570	33.67
100.00	32.57	-.4570	35.53
100.00	33.31	-.4570	26.41
100.00	33.[illegible]5	-.4570	37.30
100.00	32.33	-.4570	36.73
100.00	33.43	-.4570	28.73

100.00	33.34	-.4570	39.01
100.00	33.53	-.4570	41.39
100.00	32.57	-.4570	47.96
100.00	33.32	-.4570	50.75
100.00	33.25	-.4570	49.09
100.00	33.33	-.4570	43.99
100.00	33.57	-.4570	38.31
100.00	32.53	-.4570	42.94
100.00	33.13	-.4570	51.21
100.00	33.53	-.4570	37.10
100.00	33.81	-.4570	44.35
100.00	32.32	-.4570	47.44
100.00	33.53	-.4570	46.77
100.00	32.23	-.4570	43.51
100.00	33.31	-.4570	45.14
100.00	32.35	-.4570	45.93
100.00	33.27	-.4570	39.72
100.00	32.27	-.4570	44.76
100.00	32.33	-.4570	46.23
100.00	33.33	-.4570	43.37
100.00	33.52	-.4570	37.52
100.00	33.37	-.4570	52.22
100.00	33.74	-.4570	45.56
100.00	33.52	-.4570	43.75
100.00	33.25	-.4570	49.64
100.00	33.55	-.4570	39.01
100.00	33.55	-.4570	40.26
100.00	33.31	-.4570	41.98
100.00	32.55	-.4570	46.01
100.00	32.57	-.4570	47.00
100.00	32.23	-.4570	44.80
100.00	32.23	-.4570	44.29
100.00	32.45	-.4570	42.84
100.00	33.53	-.4570	41.37
100.00	32.28	-.4570	45.71
100.00	33.33	-.4570	45.60
100.00	33.62	-.4570	37.76
100.00	33.17	-.4570	49.37
100.00	33.51	-.4570	43.23
100.00	33.52	-.4570	49.09

100.00	33.73	-.4570	39.92
100.00	33.39	-.4570	41.07
100.00	32.53	-.4570	45.26
100.00	33.55	-.4570	51.03
100.00	33.74	-.4570	38.89
100.00	33.34	-.4570	47.20
100.00	33.32	-.4570	44.07
100.00	32.25	-.4570	48.06
100.00	33.13	-.4570	51.53
100.00	33.53	-.4570	39.40
100.00	33.33	-.4570	45.22
100.00	32.57	-.4570	45.93
100.00	33.57	-.4570	39.72
100.00	33.[illegible]	-.4570	44.13
100.00	33.33	-.4570	46.90
100.00	33.33	-.4570	45.31
100.00	33.43	-.4570	41.49
100.00	32.24	-.4570	45.38
100.00	32.32	-.4570	44.46
100.00	33.53	-.4570	43.81
100.00	32.53	-.4570	46.41
100.00	33.33	-.4570	51.71
100.00	32.53	-.4570	45.35
100.00	33.57	-.4570	40.44
100.00	33.13	-.4570	45.18
100.00	33.52	-.4570	39.35
100.00	33.51	-.4570	39.96
100.00	33.73	-.4570	45.58
100.00	32.42	-.4570	46.03
100.00	33.94	-.4570	44.31
100.00	32.27	-.4570	47.90
100.00	32.93	-.4570	45.83
100.00	32.53	-.4570	46.11
100.00	33.54	-.4570	41.29
100.00	33.43	-.4570	45.65
100.00	33.93	-.4570	47.96
100.00	33.91	-.4570	39.44
100.00	33.33	-.4570	49.40
100.00	33.73	-.4570	41.13
100.00	33.52	-.4570	40.93

100.00	33.37	-.4570	53.49
100.00	33.83	-.4570	40.18
100.00	32.44	-.4570	49.17
100.00	33.30	-.4570	44.76
100.00	33.75	-.4570	45.40
100.00	33.35	-.4570	45.99
100.00	33.30	-.4570	52.64
100.00	32.54	-.4570	51.92
100.00	33.11	-.4570	57.12
100.00	33.51	-.4570	40.28
100.00	32.43	-.4570	47.02
100.00	32.51	-.4570	47.76
100.00	33.52	-.4570	45.24
100.00	33.50	-.4570	45.65
100.00	33.72	-.4570	51.67
100.00	33.34	-.4570	39.60
100.00	33.47	-.4570	45.20
100.00	32.51	-.4570	46.27
100.00	32.54	-.4570	51.17
100.00	33.57	-.4570	45.95
100.00	33.45	-.4570	50.67
100.00	33.53	-.4570	45.69
100.00	32.43	-.4570	55.24
100.00	33.43	-.4570	42.80
100.00	33.52	-.4570	43.89
100.00	32.44	-.4570	48.61
100.00	33.57	-.4570	45.46
100.00	33.75	-.4570	51.92
100.00	32.47	-.4570	51.63
100.00	33.57	-.4570	54.15
100.00	32.57	-.4570	50.63
100.00	33.31	-.4570	40.85
100.00	32.49	-.4570	47.76
100.00	33.31	-.4570	40.50
100.00	33.21	-.4570	51.49
100.00	33.77	-.4570	45.98
100.00	33.33	-.4570	39.48
100.00	33.13	-.4570	49.23
100.00	33.72	-.4570	45.24
100.00	33.43	-.4570	53.13

100.00	33.33	-.4570	31.49
100.00	33.17	-.4570	39.31
100.00	32.44	-.4570	40.52
100.00	33.25	-.4570	34.13
100.00	33.34	-.4570	37.66
100.00	33.33	-.4570	35.44
100.00	33.23	-.4570	37.14
100.00	32.55	-.4570	40.24
100.00	33.12	-.4570	33.69
100.00	32.95	-.4570	33.06
100.00	33.55	-.4570	32.16
100.00	32.51	-.4570	35.91
100.00	33.57	-.4570	30.06
100.00	33.53	-.4570	30.71
100.00	32.43	-.4570	39.17
100.00	33.74	-.4570	33.83
100.00	33.45	-.4570	31.45
100.00	32.52	-.4570	35.91
100.00	32.54	-.4570	35.67
100.00	33.53	-.4570	34.38
100.00	33.25	-.4570	34.38
100.00	33.55	-.4570	30.75
100.00	33.71	-.4570	36.73
100.00	33.43	-.4570	30.79
100.00	33.52	-.4570	37.06
100.00	33.33	-.4570	37.62
100.00	33.51	-.4570	44.68
100.00	33.75	-.4570	36.23
100.00	32.45	-.4570	36.13
100.00	33.74	-.4570	35.18
100.00	32.44	-.4570	35.97
100.00	33.52	-.4570	29.76
100.00	32.51	-.4570	35.73
100.00	33.43	-.4570	38.79
100.00	33.31	-.4570	40.38
100.00	32.33	-.4570	35.69
100.00	33.77	-.4570	30.95
100.00	32.43	-.4570	36.96
100.00	33.73	-.4570	29.70
100.00	33.43	-.4570	34.78

100.00	33.33	-.4570	25.97
100.00	33.30	-.4570	24.40
100.00	32.47	-.4570	32.74
100.00	33.55	-.4570	34.13
100.00	32.45	-.4570	30.63
100.00	33.34	-.4570	30.40
100.00	33.23	-.4570	32.66
100.00	32.51	-.4570	31.71
100.00	33.11	-.4570	40.97
100.00	32.35	-.4570	29.27
100.00	32.43	-.4570	30.32
100.00	32.47	-.4570	30.50
100.00	33.57	-.4570	25.71
100.00	33.59	-.4570	25.67
100.00	32.45	-.4570	31.55
100.00	33.14	-.4570	30.63
100.00	33.44	-.4570	25.77
100.00	32.52	-.4570	30.87
100.00	32.54	-.4570	31.19
100.00	33.57	-.4570	26.21
100.00	33.25	-.4570	29.93
100.00	33.55	-.4570	26.96
100.00	33.70	-.4570	31.75
100.00	33.49	-.4570	25.26
100.00	33.52	-.4570	31.79
100.00	33.49	-.4570	26.87
100.00	33.50	-.4570	41.69
100.00	33.57	-.4570	25.04
100.00	32.45	-.4570	31.65
100.00	33.74	-.4570	30.14
100.00	32.44	-.4570	32.18
100.00	33.62	-.4570	25.97
100.00	32.50	-.4570	31.25
100.00	33.49	-.4570	32.38
100.00	33.31	-.4570	36.59
100.00	32.33	-.4570	30.65
100.00	33.77	-.4570	25.28
100.00	33.[illegible]	-.4570	33.45
100.00	33.73	-.4570	24.72
100.00	33.43	-.4570	32.54

10[illegible]	34.12	-.457[illegible]	29.22
10[illegible]	34.17	-.457	32.36
10[illegible]	33.55	-.4570	34.04
10[illegible]	33.57	-.4570	33.91
10[illegible]	33.53	-.4570	34.32
10[illegible]	33.58	-.4570	34.24
10[illegible]	33.31	-.4570	35.28
10[illegible]	33.63	-.457[illegible]	36.96
10[illegible]	33.34	-.4570	37.30
10[illegible]	34.15	-.4570	30.88
10[illegible]	33.75	-.4570	32.82
10[illegible]	33.43	-.457	35.20
10[illegible]	33.35	-.457[illegible]	36.71
10[illegible]	33.53	-.4570	35.17
10[illegible]	33.72	-.457[illegible]	33.11
10[illegible]	33.41	-.457[illegible]	32.67
10[illegible]	34.[illegible]1	-.457[illegible]	34.36
10[illegible]	33.41	-.4570	37.49
10[illegible]	33.45	-.457[illegible]	32.60
10[illegible]	33.34	-.4570	35.00
10[illegible]	[illegible]	-.4570	31.71
10[illegible]	33.73	-.4570	34.62
10[illegible]	33.55	-.457[illegible]	33.74
10[illegible]	34.37	-.4570	30.56
10[illegible]	33.37	-.4570	33.97
10[illegible]	33.55	-.4570	33.55
10[illegible]	34.[illegible]1	-.4570	33.24
10[illegible]	33.74	-.4570	36.33
10[illegible]	33.55	-.4570	34.85
10[illegible]	33.52	-.4570	33.55
10[illegible]	33.53	-.4570	34.63
10[illegible]	33.41	-.4570	34.73
10[illegible]	33.39	-.4570	36.86
10[illegible]	33.55	-.4570	35.05
10[illegible]	33.47	-.4570	38.26
10[illegible]	33.55	-.457[illegible]	37.94
10[illegible]	33.33	-.457[illegible]	32.47
10[illegible]	33.43	-.4570	36.93
10[illegible]	33.45	-.457	34.28
10[illegible]	33.35	-.4570	38.59

100.00	33.59	-.4570	47.33
100.00	33.93	-.4570	43.65
100.00	33.53	-.4570	45.66
100.00	33.84	-.4570	47.36
100.00	33.43	-.4570	44.56
100.00	33.35	-.4570	45.74
100.00	34.77	-.4570	45.55
100.00	33.59	-.4570	45.96
100.00	33.31	-.4570	47.73
100.00	34.73	-.4570	40.86
100.00	33.45	-.4570	44.35
100.00	33.49	-.4570	45.66
100.00	33.75	-.4570	49.05
100.00	33.45	-.4570	48.47
100.00	33.44	-.4570	47.36
100.00	33.43	-.4570	45.36
100.00	34.[illegible]3	-.4570	41.68
100.00	33.45	-.4570	48.90
100.00	33.59	-.4570	44.59
100.00	33.31	-.4570	48.45
100.00	33.53	-.4570	47.43
100.00	33.39	-.4570	48.77
100.00	33.49	-.4570	45.81
100.00	34.[illegible]5	-.4570	39.91
100.00	33.79	-.4570	47.44
100.00	33.51	-.4570	41.87
100.00	33.97	-.4570	45.87
100.00	33.74	-.4570	46.87
100.00	33.39	-.4570	46.08
100.00	33.55	-.4570	46.62
100.00	33.55	-.4570	43.33
100.00	33.57	-.4570	44.53
100.00	33.57	-.4570	42.31
100.00	33.44	-.4570	43.72
100.00	33.93	-.4570	48.67
100.00	33.52	-.4570	48.66
100.00	33.52	-.4570	40.20
100.00	33.55	-.4570	49.59
100.00	33.44	-.4570	39.83
100.00	33.95	-.4570	49.29

[illegible]	34.12	[illegible]	41.33
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	33.72	[illegible]	42.46
[illegible]	33.73	[illegible]	47.28
[illegible]	33.44	-.457[illegible]	43.29
[illegible]	33.71	[illegible]	44.99
[illegible]	[illegible]	[illegible]	44.43
[illegible]	[illegible]	[illegible]	45.97
[illegible]	[illegible]	[illegible]	52.67
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	33.53	[illegible]	46.55
[illegible]	33.53	[illegible]	47.64
[illegible]	33.35	[illegible]	45.76
[illegible]	33.37	-.4570	42.25
[illegible]	33.45	[illegible]	42.92
[illegible]	33.33	[illegible]	41.86
[illegible]	[illegible]	[illegible]	44.36
[illegible]	33.43	-.457[illegible]	46.06
[illegible]	33.43	-.457[illegible]	41.32
[illegible]	33.33	[illegible]	47.50
[illegible]	33.55	[illegible]	43.31
[illegible]	33.35	[illegible]	44.28
[illegible]	33.43	[illegible]	43.38
[illegible]	33.55	[illegible]	43.37
[illegible]	33.79	-.457[illegible]	44.39
[illegible]	33.54	[illegible]	44.34
[illegible]	33.33	-.4570	42.16
[illegible]	33.74	[illegible]	45.82
[illegible]	33.57	-.4570	44.99
[illegible]	33.55	[illegible]	43.51
[illegible]	33.53	-.4570	41.98
[illegible]	33.43	[illegible]	42.80
[illegible]	33.43	-.4570	43.39
[illegible]	33.44	-.457[illegible]	44.29
[illegible]	33.54	-.4570	44.12
[illegible]	33.53	[illegible]	44.92
[illegible]	[illegible]	[illegible]	41.74
[illegible]	33.53	[illegible]	45.29
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	33.33	[illegible]	[illegible]

10[illegible]	34.1[illegible]	-.[illegible]57[illegible]	4[illegible].58
10[illegible]	3[illegible].14	-.[illegible]57[illegible]	39.44
10[illegible]	33.54	-.[illegible]57[illegible]	43.37
10[illegible]	33.55	-.[illegible]57[illegible]	43.85
10[illegible]	33.53	-.457[illegible]	43.61
10[illegible]	33.53	-.[illegible]57[illegible]	43.83
10[illegible]	33.31	-.[illegible]57[illegible]	47.13
10[illegible]	33.53	-.[illegible]57	44.73
10[illegible]	33.34	-.457[illegible]	45.63
10[illegible]	34.[illegible]3	-.[illegible]57[illegible]	39.87
10[illegible]	33.43	-.[illegible]	42.77
10[illegible]	33.[illegible]5	-.[illegible]57[illegible]	43.55
10[illegible]	33.71	-.[illegible]57[illegible]	47.27
10[illegible]	33.52	-.457[illegible]	42.[illegible]9
10[illegible]	33.75	-.[illegible]57[illegible]	43.81
10[illegible]	33.45	-.[illegible]57[illegible]	44.41
10[illegible]	3[illegible].1[illegible]	-.[illegible]57	43.34
10[illegible]	33.33	-.457[illegible]	46.31
10[illegible]	33.57	-.[illegible]57[illegible]	44.64
10[illegible]	33.31	-.[illegible]57[illegible]	42.25
10[illegible]	33.53	-.457[illegible]	43.11
10[illegible]	33.35	-.[illegible]57[illegible]	44.11
10[illegible]	33.42	-.[illegible]57[illegible]	42.52
10[illegible]	3[illegible].[illegible]2	-.[illegible]57[illegible]	39.69
10[illegible]	33.31	-.457[illegible]	48.12
10[illegible]	33.77	-.457[illegible]	43.85
10[illegible]	34.15	-.457[illegible]	45.54
10[illegible]	34.21	-.457[illegible]	40.87
10[illegible]	33.42	-.457[illegible]	44.44
10[illegible]	33.42	-.457[illegible]	43.06
10[illegible]	33.57	-.457[illegible]	44.77
10[illegible]	33.33	-.457[illegible]	43.73
10[illegible]	33.43	-.457[illegible]	43.52
10[illegible]	33.43	-.457[illegible]	45.16
10[illegible]	33.53	-.[illegible]57[illegible]	43.06
10[illegible]	33.57	-.[illegible]57[illegible]	44.13
10[illegible]	33.53	-.[illegible]57	43.89
10[illegible]	33.52	-.[illegible]57[illegible]	44.84
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[illegible]	33.94	-.457[illegible]	39.17
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1[illegible]	33.73	-.[illegible]57[illegible]	3[illegible].14
1[illegible]	33.33	-.[illegible]57[illegible]	36.4[illegible]

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1[illegible]	33.35	-.[illegible]57[illegible]	34.76
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1[illegible]	33.73	-.457[illegible]	35.94
1[illegible]	33.73	-.[illegible]57[illegible]	34.38
1[illegible]	33.33	-.[illegible]57[illegible]	3[illegible].29
1[illegible]	33.93	-.[illegible]57[illegible]	36.44
1[illegible]	34.[illegible]9	-.457[illegible]	35.76
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1[illegible]	3[illegible].[illegible]5	-.[illegible]57[illegible]	39.06
1[illegible]	34.[illegible]7	-.457[illegible]	35.04
1[illegible]	34.[illegible]2	-.457	37.72
1[illegible]	33.34	-.[illegible]57[illegible]	36.[illegible]4
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100.00	34.33	-.4570	41.08
100.00	33.99	-.4570	48.45
100.00	34.09	-.4570	49.97
100.00	33.35	-.4570	44.90
100.00	34.17	-.4570	48.08
100.00	34.07	-.4570	44.73
100.00	33.99	-.4570	43.41
100.00	34.20	-.4570	46.56
100.00	34.15	-.4570	42.87
100.00	33.35	-.4570	51.74
100.00	34.04	-.4570	47.17
100.00	33.30	-.4570	47.36
100.00	33.93	-.4570	46.17
100.00	34.02	-.4570	45.51
100.00	33.92	-.4570	45.45
100.00	34.13	-.4570	41.47
100.00	33.94	-.4570	51.83
100.00	33.33	-.4570	45.44
100.00	34.37	-.4570	46.38
100.00	33.92	-.4570	44.66
100.00	34.25	-.4570	47.23
100.00	33.37	-.4570	45.25
100.00	34.07	-.4570	43.33
100.00	33.99	-.4570	49.51
100.00	34.21	-.4570	41.22
100.00	34.09	-.4570	43.62
100.00	34.19	-.4570	43.02
100.00	34.05	-.4570	46.57
100.00	34.00	-.4570	45.73
100.00	34.07	-.4570	45.03
100.00	34.22	-.4570	41.88
100.00	33.91	-.4570	45.03
100.00	34.02	-.4570	47.98
100.00	33.85	-.4570	46.73
100.00	33.94	-.4570	46.52
100.00	34.20	-.4570	41.61
100.00	33.33	-.4570	52.33
100.00	33.97	-.4570	42.33
100.00	33.91	-.4570	52.41

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10[illegible]	34.39	-.4570	48.63
10[illegible]	33.33	-.4570	46.77
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10[illegible]	33.33	-.4570	44.77
10[illegible]	33.33	-.4570	45.62
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10[illegible]	34.33	-.4570	45.27
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10 .00	34.03	-.4570	47.08
10 .0	34.19	-.457	48.78
10 .00	34.32	-.4570	43.45
10 .0	33.93	-.4570	45.22
10 .00	34.02	-.4570	46.29
10 .	33.93	-.4570	47.02
10 .00	34.03	-.4570	48.41
10 .	33.37	-.457	45.09
10 .00	33.93	-.4570	48.42
10 .00	34.33	-.4570	47.02
10 .00	34.07	-.4570	45.90
10 .00	33.93	-.4570	46.40
10 .00	34.01	-.4570	47.13
10 .	33.91	-.457	46.22
10 .	34.08	-.4570	43.23
10 .	34.08	-.4570	49.37
10 .	33.92	-.4570	45.82
10 .	34.05	-.4570	49.69
10 .00	33.92	-.4570	46.86
10 .00	34.01	-.4570	49.19
10 .	34.07	-.4570	47.47
10 .00	34.01	-.4570	46.65
10 .00	34.25	-.4570	49.42
10 .00	34.21	-.4570	41.15
10 .00	33.95	-.4570	47.98
100.00	34.29	-.4570	41.97
10 .0	34.02	-.4570	48.62
10 .00	34.01	-.4570	46.38
10 .00	34.35	-.4570	46.16
100.00	34.21	-.4570	44.20
10 .00	33.94	-.4570	44.89
10 .00	34.19	-.4570	43.28
10 .0	33.32	-.4570	47.75
10 .00	33.37	-.457	47.43
10 .00	34.31	-.4570	39.66
10 .00	34.11	-.4570	49.02
10 .00	34.22	-.4570	4 .23
10 .00	3 . 8	-.457	.58

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100.00	34.23	-.4570	35.37
100.00	34.[illegible]7	-.4570	40.04
100.00	33.33	-.4570	43.58
100.00	33.32	-.4570	36.33
100.00	33.33	-.4570	35.85
100.00	33.93	-.4570	35.99
100.00	33.93	-.4570	42.28
100.00	34.10	-.4570	46.35
100.00	34.15	-.4570	31.16
100.00	34.[illegible]3	-.4570	42.90
100.00	34.[illegible]1	-.4570	36.79
100.00	34.[illegible]4	-.4570	43.90
100.00	33.39	-.4570	39.78
100.00	34.[illegible]1	-.4570	40.97
100.00	33.90	-.4570	39.78
100.00	34.13	-.4570	32.75
100.00	34.[illegible]5	-.4570	42.23
100.00	33.37	-.4570	39.37
100.00	34.[illegible]5	-.4570	41.96
100.00	34.[illegible]2	-.4570	37.40
100.00	34.10	-.4570	44.05
100.00	34.[illegible]2	-.4570	37.28
100.00	34.[illegible]4	-.4570	37.70
100.00	34.25	-.4570	45.54
100.00	33.95	-.4570	35.77
100.00	34.[illegible]3	-.4570	41.63
100.00	34.30	-.4570	36.09
100.00	33.93	-.4570	38.89
100.00	34.05	-.4570	36.11
100.00	34.[illegible]3	-.4570	39.58
100.00	33.91	-.4570	39.00
100.00	33.93	-.4570	37.46
100.00	33.92	-.4570	37.97
100.00	33.31	-.4570	40.10
100.00	34.[illegible]3	-.4570	41.29
100.00	3[illegible].45	-.4570	32.63
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100.00	34.[illegible]	-.4570	43.85

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10.[illegible]	34.23	-.4570	41.13
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10.[illegible]	34.22	-.4570	43.41
10.[illegible]	34.37	-.4570	42.02
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10.[illegible]	34.33	-.4570	45.12
10.[illegible]	34.15	-.4570	41.71
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10.[illegible]	34.45	-.4570	40.96
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10.[illegible]	34.31	-.4570	40.66
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VITA

John Joseph Alt was born on August 31, 1949 in Ft. Wayne, Indiana. He was raised in the midwest and graduated from Andrean High School in 1967. He attended St. Joseph's College (Indiana) from which he received the degree of Bachelor of Science in Physics in June 1971. He was commissioned in the United States Air Force on completion of Officer Training School in September 1971. He completed navigator training and received his wings in July 1972 and electronic warfare training in February 1973. He served as a B-52 electronic warfare officer (EWO), an instructor EWO, and an EWO flight examiner with the 596th Bomb Squadron (Heavy), Barksdale AFB, Louisiana (1973-1977) and with the 43rd Strategic Wing, Andersen AFB, Guam (1977-1979). He entered the Air Force Institute of Technology in August 1979. He is married to the former Sharon E. Rayfield of Lancaster, S. C. He and his wife have a daughter, Heidi, and a son, Jeremy.

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4 OF 4
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